ICTD State of the Union: Where have we reached and where are we headed

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***Abstract*— In this study we examine the history and growth of ICTD since the 1990s. We underline the trends defining this research field and examine the progress in research areas that have come to dominate discussion in ICTD through a thorough literature review of the last decade of ICTD work. In order to answer questions pertaining to the rigor, impact and significance of ICTD, and to compare the expectations and perceived achievements with respect to different development goals, we interview 50 expert ICTD researchers and practitioners. We analyze these results to understand stakeholders' opinions on the past performance of ICTD, both as an academic field and as an area of development practice, and identify defining ideas on the potential directions for the future of ICTD. This study is work in progress and we have continuing research in this area, the subset presented here is rigorous and ready for wider discussion.[1]**

***Index Terms*— ICTD, developing world**

I. Introduction

THE Scandinavians started it. It may be a lost piece of trivia somewhere, but ICTD as we know it began with the community computer rooms in Scandinavian villages. Starting with the first village (Fjaltring in Denmark), there were several small tele-cottages throughout Sweden, Denmark and Norway by 1985, and it wasn't until a few years later that Sri Lanka became the first developing country to get its community technology access center [1].

The term ICTD started appearing in academia and industry with minor alphabetical variances such as ICT4D, ICT4B (billions), IT4D and so on by the mid 1990s. The years preceding this were formative in the growth of interest in the subject around the world. The opening up of Eastern European economies coincided with phenomenal periods of growth in China and India. The technology boom in the United States featured a large pool of engineers from various parts of the developing world. The spillover economic effects of this international technology workforce ranged from remittances to home countries to the creation of new small and medium-scale engineering companies [2, 3]. The public discourse of technology as being an engine of macroeconomic growth grew in strength rapidly as the early impacts of globalization in the tech industry manifested themselves first in the West, and soon thereafter in many parts of the developing world. The international faces of this phenomenon often were transnational expatriate technologists from the developing world.

By the mid 1990s, there was significant buzz on the role of the information technology boom in dramatic global change [4, 5], and a first generation of ICTD literature discussing the specific nature of technology projects in development started a worldwide interest in the field [6-10]. Around this period, there was a dramatic rise in the number of 'ICTD Projects' – i.e., technology projects specifically aimed at creating developmental outcomes for their recipients. This trend was partly driven by a slew of research papers and policy documents within international agencies [11-13]. As a result, by the turn of the century, there were thousands of telecenters around the world, funded through various sources [14].

By the early 2000s, engineers became interested in ICTD, not just as a development agenda, but as an area that posed interesting research problems in their own fields of work [15-19]. This followed the establishment of numerous academic venues, both as part of existing established forums, and independent venues specifically for the study and discussion of ICTD.

Following this early foundational scholarly and practitioner work, more interesting follow-up work has been done on emergent areas of ICTD including digital inequality [20-23], on technology and sectoral development and macroeconomic change [24-26], on technology and urban change [10, 27], and on the 'potential' of technology [12, 28, 29]. By the mid 2000s, there was introspective work looking at the performance of the ICTD projects started in the 1990s in India and elsewhere, and also at the causes and outcomes of the interest in technology and development [30-33]. More recently, scholars have looked back at the growth of ICTD through the years by tracing the various stages that ICTD has moved through in this period [34].

Our survey and research here hope to build on such work. As stakeholders in an emerging field of study that is still in the process of defining itself and carving a niche, it is critical that we look back at various points in our progress and review the direction of our growth. Here, we present a fairly comprehensive survey of what has happened in the field, and use the opinion of significant voices from the field to support the literature review, in the hope of shedding some light on the general direction of ICTD work and its validity. We examine

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the progress in dominant ICTD research areas, we identify the areas that received more attention in previous research, and we compare the expectations with the perceived achievements in each of these areas. We also examine questions concerning the rigor, impact and significance of ICTD, and its appropriateness in serving various development goals.

II. Approach

We begin our study by categorizing some broad domains of ICTD research and practice, and by performing a high-level overview of the progress in each of these domains. We follow this by presenting the results of our interviews with ICTD experts on their opinions about research and practical work in each of these areas.

In addition to these discussions, we consider a few recurring themes in our early conversations with interviewed researchers. The first emergent theme was the question of 'Hope v/s Hype' in the context of ICTD. This issue, has been explored in the past [35-37], but continues to remains a niggling issue for most practitioners and researchers alike, who face up to it in their own work. A related theme that emerged in our interviews has been that the role of various stakeholders. As ICTD moves from being an experimental area towards mainstream development research and practice, it is inevitable that we face hard questions about what the role of government should be in funding ICTD projects, what kind of ICTD projects are more likely to succeed and so on. Posing these questions to our interviewees, we find an interesting variance of opinion on this issue. Finally we explore issues about the interdisciplinary nature of ICTD – how far does it exist, and has it helped or impeded ICTD.

III. Methodology

The research consists of two parts – first, an extensive literature review of the various projects in ICTD over the past decade, and second, a survey of 50 researchers and practitioners in the ICTD space. The two were done simultaneously – i.e. while we had some idea of what the broad literature review would bring up, we had no idea of how similar it would be to the results from our interviews.

A. Instrument Design

The interview schedule was created over three iterations on the basis of feedback about the interview questions from researchers in our direct contact. The third version of the questionnaire was an online hybrid with a mix of open-ended and close-ended questions, of which the former were created based on categories arrived upon in the first two iterations of the instrument. The final interview was anonymized and took anywhere between 15-75 minutes to complete, depending on the interviewee.

B. Sampling and Recruitment

We had a selective sample of respondents from a few major ICTD-related online forums, in addition to other professors and researchers that we contacted to fill out the survey.

C. Sample description

Our total sample included 50 respondents, who were asked to select their areas of affiliation. We observe a fairly even distribution of these areas, with a slight skew towards education and infrastructure. Overall, a higher number of researchers than practitioners were represented in this survey.

TABLE I
Respondent description by areas of affiliation

Domain Area	Research	Practice
Healthcare	11	3
Education	17	7
Business	8	4
Agriculture	8	3
Comm. & network infrastructure	16	4
User interface design	11	0
Governance	10	1
Other	9	3

The respondents' past academic disciplines (regardless of whether they are presently scholars or practitioners) were fairly evenly distributed between science/engineering, social sciences, and hybrid areas such as design and information studies.

TABLE II
Respondent by areas of primary academic specialization

Academic Discipline	Number of Respondents
Engineering	16
Information Studies	7
Education	3
Political Science	4
Design	2
City planning	2
Sociology	2
Humanities	2
Media	2
International business and relations	2
ICTD	2
Development Studies	1
Anthropology	1
Agriculture	1
Commerce	1
Physics	1
Environmental Science	1
Total	50

D. Caveats

The findings are from a fairly small sample because we wanted experts with several years in the field to comment on ICTD issues rather than a broad-based survey of a large number of participants. Over half of our sample is represented by people who have been active in ICTD for over 5 years and are thus familiar with the landscape and the changes in ICTD and are qualified to comment on past and future issues. That said, such a small and selectively sampled survey is prone to bias. This study is a work in progress, and while the results presented here are rigorous and sturdy enough for discussion, there is always scope for increasing the sample size, and finding out through an iterative process what areas might need better coverage in the questions.

Finally, one other important caveat here is the regional concentration of respondents. We find a very heavy skew towards respondents currently based in the US and India, but this is explained by the fact that US is somewhat of a hub for researchers and practitioners, and that a large fraction of the ICTD activity is located in India. This also seems to indicate that academics from developing countries are going abroad to study ICTD in American or European Universities.

TABLE III
LOCATION OF RESPONDENT AND REGIONAL FOCUS

Country	Physical location of Respondent	Location where respondent primarily active in ICTD work
USA	25	4
India	10	20
Malaysia	2	1
Philippines	2	2
Barbados	1	1
Brazil	1	1
Ghana	0	2
Botswana	0	1
Chile	0	1
Colombia	0	1
Canada	1	0
Greece	1	0
Netherlands	1	0
Nigeria	1	0
South Africa	1	1
Spain	1	0
Sweden	1	0
Switzerland	1	0
Uganda	1	0
Macedonia	0	1
Nigeria	0	1
No Specific Region	--	12
Total	50	50

IV. FINDINGS

A. Healthcare

The interest in using technology to widen access to healthcare and sanitation pre-dates the ICTD age. While earlier initiatives focused on increasing access to specialists and getting basic diagnosis to remote regions within the developed world [38], recently, the UN Millennium development goals (MDGs) have renewed the focus on ICTD [39, 40]. There are four broad areas where active ICTD projects tackle healthcare challenges. The first has been telemedicine [41], and here the focus has been on using long-distance communication links to expand access to remote rural areas where there are no doctors. For-profit initiatives have been deployed for specific kinds of diagnoses that can be reasonably well managed remotely, such as ophthalmology and dermatology [42].[2] The second area of ICTD interest in healthcare is information gathering especially for epidemiological research. There have been a number of projects focusing either on general population health surveying, patient health monitoring, or healthcare aid impact assessment [43, 44]. A third focus of ICTD was driven by expatriate doctor communities from developing countries who were interested in contributing back to their home countries through social initiatives. Some ICTD projects have used web 2.0 technologies to connect doctors in the developing world with counterparts and experts in the developed world for remote consulting on specialty care [45]. The fourth area of ICTD in healthcare has concentrated on the use of technology in building low-cost medical diagnostic devices (such as ultrasound, X-ray machines) and sensors.[3]

We asked respondents in the study to name the areas of ICTD and healthcare that they felt were of significance looking into the future. The top 5 responses, from a subset of 36 who commented on healthcare, are presented in the following table:

TABLE IV
AREAS OF FUTURE IMPORTANCE IN HEALTHCARE

Top 5 areas ranked by respondents	Percent Respondents
Medical records	57.8
Supply-chain management	50.0
Tele-diagnosis and treatment	44.7
Collection of epidemiological data	44.7
User interfaces	28.9

From the interview results, it stands out that supply chain management in healthcare and the design of user interfaces for

[2] http://www.clickdiagnostics.com

[3] Several of the Microsoft Research Digital Inclusion grantees in 2005 were doing some work in healthcare, at least two were specifically designing low-cost diagnosis devices for developing countries. http://research.microsoft.com/ur/us/fundingopps/RFPs/DigitalInclusion_2005_RFP_Awards.aspx

healthcare work were both seen as very important areas for future effort, though both of these are practically absent in our literature review of past work. Medical records, collection of epidemiological data, and tele-diagnosis, all areas with important past work were also viewed as very relevant by respondents. In addition to these, a number of respondents mentioned health education and emergency assistance for locating medical facilities are potentially strong areas for the future. There was surprisingly very little mention of low-cost diagnostic devices.

B. Agriculture

From the earliest ICTD implementations in developing countries, the apparent incongruity of computers in the rural hinterland has been a key concern for researchers. We see therefore that many early projects tried to increase the relevance of computing in rural areas by providing information on agricultural practices, market prices and government schemes through telecenters [46, 47]. However, persuading rural adults to be regular telecenter users has been a challenge. As a result, besides agriculture, many telecenters have also focused on other services such as online assistance to help small enterprises in villages, for instance, artisans that sell handicrafts on the Internet [48]. There has also been work on turning telecenters into points of purchase in supply chains for rural produce [49].

Other kinds of ICTD projects in the rural agricultural market include the use of cellphones and PDAs in organic certifications for farmers [50], sensor networks in helping water management for rural areas [51], livestock management [52], price information [53] and farming extension and information sharing [54]. With the growing interest in micro-entrepreneurship, the use of technology to increase access to microfinance has been very prominent in ICTD research. Many projects have attempted to implement technological solutions to assist on-the-ground rural microfinance operations [55, 56]. Work in social sciences has examined whether the ability of technological interventions in increasing the efficiency of rural microfinance operations depends largely on the scale of operations of the organization adopting the technology intervention [57]. A survey of respondents on their opinion about the key areas in agriculture revealed the following:

TABLE V
AREAS OF FUTURE IMPORTANCE IN AGRICULTURE

Top 5 areas ranked by respondents	Percent Respondents
Best practices and information sharing	56.7
Market access and information	51.3
Supply chain management	45.9
Sensors	21.6
Access to expert information	18.9

Unlike in the case of healthcare, the responses for agriculture closely matched past work on agriculture within ICTD, and most respondents were in fairly good agreement about the perceived progress in these areas. What is worth noticing here is that 'access to expert information' which had been one of the most important areas of concern in the early days of ICTD takes a lower position, whereas market access and information, despite the apparent challenges in making market information usable for actual transactions, remains a top concern for ICTD experts.

C. Education

Governments, philanthropic efforts, and private corporations have all found the ICT in education space to be attractive right from the earliest days of ICTD implementations. Many of the early 'low-cost computing' projects such as the Hewlett Packard's 4-4-1 computer,[4] and the Computador Popular were aimed at classroom use [58]. Computer aided learning projects have been among the largest and most prominent project categories within the ICTD space in the last decade, and today, it is arguably true that more poor households have "access to technology" through a child in school than through a kiosk or any other means of computer access [59]. Impact of computers on learning is an area of ICTD that has seen interest from mainstream economics as well [60]. Interface designers have been actively looking at innovative learning methods with computers and a lot of interesting work has been done in shared computing [61], cellphones for game-based learning [62], and networked systems for contextual classroom video instruction [63].

In higher education, distance learning in developing regions has been an early area of interest within ICTD [64, 65]. While a significant chunk of the work with children has been India-centric, we find a lot of work in higher education elsewhere, including the use of SMS for question/answers in university lectures [66] in Bangladesh, cellphones for interactive learning [67] in the Philippines, and a one-mouse-per-desk approach for lectures [68] in China.

TABLE VI
AREAS OF FUTURE IMPORTANCE IN EDUCATION

Top 5 areas ranked by respondents	Percent Respondents
Remote learning	31.4
Educational games	25.7
Low cost computing	22.8
Life-long learning	17.1
Online content	14.2

There was far lesser agreement in the education space on the key areas of research among ICTD experts. Two interesting factors emerged in our discussions. First, that low-cost computing, which has attracted a lot of interest in recent years, is seen comparatively as a less important area of research than working with existing devices. This mirrors well

[4] http://www.hp.com/e-inclusion/en/project/441_brochure.pdf

the general frame of discussion within existing ICTD literature, which has also largely taken the same position. The second important issue is that remote learning, in which we have seen some promising projects start in the last few years, is expected to continue to be an area of focus in the coming years.

D. Communications and Infrastructure

Among the earliest areas to get engineering scholars interested in ICTD was the challenge of building and deploying novel high quality communication network solutions to connect low income regions with poor legacy infrastructure. Studies suggested that communications backbones could be the first form of infrastructure that would be affordable to deploy in the developing world [15] and that this could in turn be a major driver for wider socio-economic growth [28]. Several projects looked at various inexpensive connectivity solutions both over the short and the long-haul [69], and the use of low-cost WiFi for long-distance connectivity became an important ICTD pursuit, with groups from several parts of the world looking at the scope of this technology in real world deployments [16, 70-73]. Today, long distance connectivity using WiFi has made significant progress showing test throughputs of upto 6 Mbps at almost 400 km distances[5] and enabling functional field deployments for telemedicine applications [42, 74]. Research has also focused on creating appropriate front-end infrastructure to work on low power and unreliable, or intermittently connected networks [75, 76].

Finally, the 'low-cost computer' has been one of the most important areas of work in technology infrastructure in ICTD, and probably the area that has generated the greatest amount of industry interest. We found over 50-projects in the past 10 years in this space including many such as Fulong Mini-PC[6], and E-DUC[7], Sirius[8], and SofComp[9] that originated from research labs in the developing world alongside work by big corporations such as Intel's Classmate[10], and AMD with its PIC[11].

TABLE VII
AREAS OF FUTURE IMPORTANCE IN COMMUNICATIONS

Top 5 areas ranked by respondents	Percent Respondents
Wireless/Low cost infrastructure	41.7
Low cost phones and devices	30.6
Mobile phones & phone coverage	22.2
Community radio & TV	22.2
VoIP	19.4

The results in this category could possibly be seen as underlining the distinction between the interests of researchers and those of the industry. Our sample, despite being open to researchers and industry, had a much higher research component. As a result, we see that low-cost infrastructure, undeniably a major area of concern for ICTD, trumps the low cost phones and devices, the area that shows more activity in our literature review. However, this could also be seen as indicative of what experts feel about the progress of low-cost devices in the real world market. Although we list a large number of low-cost device projects here, only a small fraction of them have actually made any significant impact in the market, and even some of the largest players abruptly left the market. It is also important that most of the research on low-cost devices is on computers, and little or no work exists on making low-cost mobile handsets, though a number of researchers indicate that this is likely to change looking ahead. One potential reason for why work on cellular infrastructure has remained largely unaddressed in ICTD came from the respondents. Several interviewees stated that since worldwide cellular coverage has grown so dramatically over the last few years, cellular coverage is seen as more of an industry problem rather than an academic research area. Furthermore, the closed protocols of dominant cellular technologies are not open to experimentation, and thus harder for researchers to work with.

E. Governance

E-Governance was a major buzz area in the early days of the ICTD, especially given a general subscription to the view that a lot of the problems of development are because of bad governance [77]. This was especially so in places like India, which had seen sluggish growth in several sectors that were tightly controlled by the state, but in sectors where the state kept itself off, growth came speedily and significantly [26]. Consequently, several projects emerged throughout the late 1990s to increase the use of technology in the processes of governance, first in the developed world and eventually in the developing world [78]. These included projects that migrated a number of state functions online as a way to reduce the manpower cost of governmental transactions [79], enable e-payments [80] and e-voting [81], and presumably also reduce the scope for corruption. A number of projects also fundamentally changed certain state functions such as land record maintenance [82].

The status on ICTD in governance thus far has been fairly mixed. Although on one hand some studies have shown generally positive feedback [83, 84], others have raised serious questions about their impacts on the disempowered [85, 86, 87].

TABLE VIII
AREAS OF FUTURE IMPORTANCE IN GOVERNANCE

Top 5 areas ranked by respondents	Percent Respondents
Sharing of public information	47.3
Digitization of records (land, tax)	31.5
Improved transparency, corruption reduction	26.3

[5] http://radar.oreilly.com/2007/06/wifi-record-range-now-382-km.html
[6] http://www.lemote.com/
[7] http://www.e-duc.com/
[8] http://www.fiveriverstech.com/sirius.htm
[9] http://www.ncoretech.com/mobilis/index.html
[10] http://www.classmatepc.com/
[11] http://50x15.amd.com/en-us/

E-payment and online retailing	23.6
E-voting	7.8

The responses from our experts on governance again mirrored fairly closely what we found in the literature review – public information, digitized land and tax records were viewed to be the most relevant research areas. There were also a small number of respondents who felt that e-voting and GIS-related work, both of which have been looked at only to a limited extent, may be among the major areas for ICTD and governance in the near future.

F. Design

The User Interface (UI) design community has been among the major technical drivers of ICTD research. The basic assumption with UI work in ICTD has been that most technologies prevalent in markets today are designed with high income, educated users in mind, and that re-designing computers and peoples' interactions with computers could make technology more accessible for the poor and illiterate [88]. Among the earliest ICTD projects – the Simputer [89] had an explicit interface design goal to make the computer a simpler device to use, therefore with few alphabetical keys, and more audio-based interactions. In most of the low-cost computing projects that followed thereafter [90], including most prominently the OLPC, appropriate UI design was a very important component [58].

Significant design work has also been done on building visually enhanced interfaces for illiterate users [91] and speech based systems for agriculture [92] and healthcare [93]. Other design work has looked across domains to redesign existing devices for new application areas – such as innovating with small screens on mobile devices for systematic data collection for healthcare [94, 95], micro-finance services for the illiterate [55], and audio-visual based English-language education [96] delivered in local languages.

TABLE IX
AREAS OF FUTURE IMPORTANCE IN DESIGN

Top 5 areas ranked by respondents	Percent Respondents
Voice recognition and synthesis	57.1
Local language software	54.2
Translation	20.0
Accessibility	17.1
Illiterate-friendly interfaces	14.2

In the design area, spreading technology access to populations without English (or other dominant) -language literacy was a major concern for researchers, thus language localization and voice recognition topped the list of future research directions. What is interesting here is that work in both these domain areas is extremely challenging and steps forward have been slow thus far. Due to current technology limitations, voice recognition cannot be an effective replacement for other technologies – so while speech can work well for small vocabularies and limited UIs, these tasks can also be done equally effectively by inexpensive visual interfaces or numerical keypads. The applications where speech could really be helpful, for example in complex transactions, is also where the technical challenges are greatest.

G. ICTD Stakeholders

One of the interesting questions around ICTD from its earliest days has been the role of various stakeholders in supporting such projects. There were a large number of ICTD projects in the 1990s, a period marked by the increasing privatization of development funding [97] and a massive boost in Corporate Social Responsibility (CSR) funding, which in turn diverted philanthropic funds from companies interested in human development towards ICTD projects [98, 99]. Because ICTD projects are often at the crossroads of business, technology and human development, many initiatives have been supported by large private corporations such as HP, Intel, or Microsoft, especially when there is an intersection of their business interests with ICTD [100]. What is more interesting is that ICTD projects have frequently been couched in a discourse of 'sustainability' [101] raising questions on whether these projects should be market driven, and we have seen some research in recent years suggesting that the state should reconsider spending on ICTD projects, specifically telecenters [59]. However, these questions are not easy to answer – the nature of development projects requires that a range of stakeholders work closely together, and ICTD is no different.

In looking at how ICTD research can be divided up between various stakeholders, we asked respondents to comment on what they felt were important roles for industry-based research to play.

TABLE X
AREAS OF FUTURE IMPORTANCE FOR BUSINESS STAKEHOLDERS

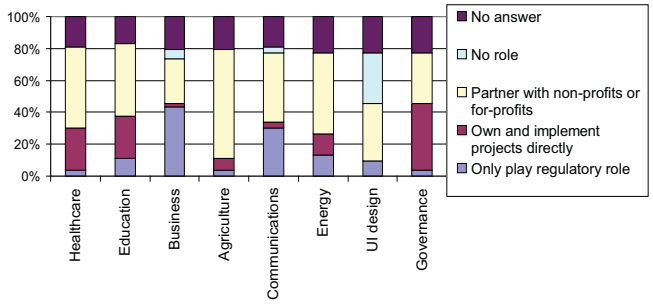
Top 5 areas ranked by respondents	Percent Respondents
Microfinance and microcredit	41.7
Mobile commerce	41.7
Supply chain management	16.7
Online commerce	13.9
Low cost sales devices	13.9

This is an interesting question which needs further examination – on whether markets ought to decide what research agenda is better served by the industry, and where academia should play a role. The surveyed experts seemed to feel that most areas typically involving financial transactions are best left to the industry. We asked respondents which stakeholder does ICTD play for – does it serve a greater development agenda or a greater business agenda – the

respondents were evenly split – a third believing the development agenda was better served, another third believing that ICTD worked better for business.

We turn now to the respondents' perceptions of where the government's role in ICTD ought to be, and as we find, most of the answers are fairly intuitive – regulate communications, directly act in healthcare, education, governance, stay out of design and so on. An interesting finding was that very few of the experts felt that the government should be directly owning ICTD projects in agriculture, most respondents preferring a hybrid role instead. This is a fairly unexpected, because in the earlier days of ICTD, the government's role in e-agriculture was seen as very important. This could perhaps tie in with the experiences with telecenters and e-agriculture run by state agencies in the past decade, which have often suffered mixed fortunes, usually weak.

FIGURE I
ROLE OF GOVERNMENT IN ICTD



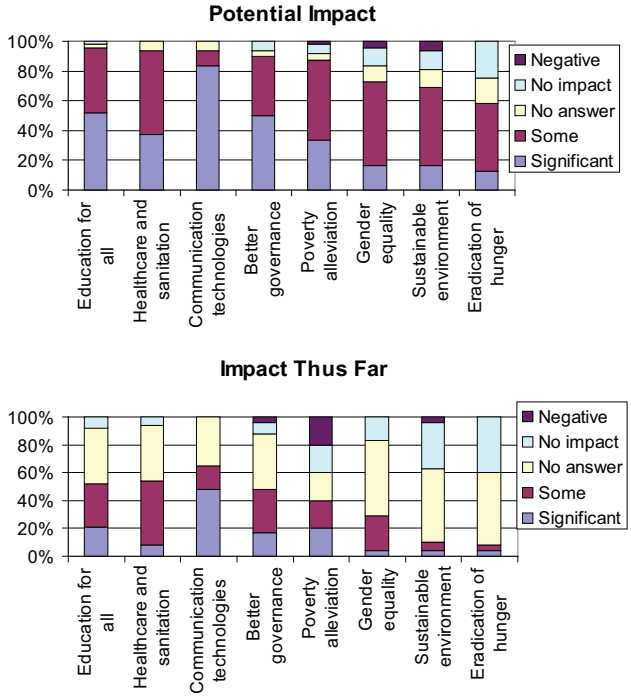
V. COMMENTARY

After analyzing ICTD research and practice through the lens of individual research sub-areas, take step back to think about the bigger issues in the field that appear as a theme throughout the area. The first of these themes is the well-known debate on "hope v/s hype", on expectations v/s reality that surrounds our field. Our literature review as well as conversations with experts on the matter suggests that the main concerns raised by existing studies were over whether ICTD stakeholders – either implementers or funding partners – made incorrect assumptions about the nature of the expected development outcome of some technology projects. Many reasons are mentioned as being responsible for these effects, including the changing nature of development goals around sustainability, and changing stakeholders with a new breed of technologists entering the development fray [100]. The opinion of ICTD experts further suggests concerns regarding the "hype" aspect: when asked whether they believe ICTD was hyped, 52% of our respondents responded affirmatively, and roughly 30% felt there wasn't any hype.

To further investigate the gap between what has been expected from ICTD and what ICTD has already achieved, we interviewed respondents on what they felt was the potential of ICTD research to make an impact in achieving various MDGs and on how far work in ICTD over the past few years had achieved that potential. Figure I presents a summary of our results, with development goals ordered (from left to right) by the fraction of interviewees that believed ICTD can make an impact (either "significant impact" or "some impact") towards that goal. For example, almost 100% of the survey takers believed that ICTD has the potential to make an impact in education for all, while only about 60% believed the same about eradication of hunger.

The first thing to note it that most experts felt that ICTD projects generally had potential, but that it had a significant way to go in achieving it fully. This is reflected by the fact that a large number of respondents chose not to answer questions on the perceived impacts of ICTD thus far, but also by the fact that few respondents believed that existing ICTD work has made a significant impact. The areas where most respondents felt there was potential for impact (either some impact or significant impact) were in education, healthcare, communications, and better governance. The area where the overwhelming majority believed the impact to be significant was in communication technologies. Other areas of development such as sustainable environment and eradication of hunger were comparatively seen as outside the scope of ICTD. One remarkable trend we find is that 20% of the respondents' opinion was that ICTD had an overall negative impact on poverty alleviation, and a small percent felt there was a negative impact on governance as well. While in both categories the proportion of respondents who felt that the impact was positive was either equal or higher, this is nonetheless a real concern that all of us engaged in serious ICTD research need to ask ourselves – whether technologies pose the serious risk of increasing inequalities.

FIGURE II
COMPARISON OF RESPONSES ON POTENTIAL AND ACTUAL IMPACT OF ICTD



To comment on the relative importance and research maturity of each of these areas, we also did a quick survey of the publishing record in the past two iterations of the ICTD conference

TABLE XI
ICTD CONFERENCE PAPERS ARRANGED BY THEMATIC AREAS

Domain Area	**No. of papers**	Sub-topics
Agriculture	7	Sensors (2) Best practices / information sharing (2) Supply chains (2) Market access / information (1)
Education	10	Literacy (2) Novel input devices (2) User-created content 2 Computer usage models (2) Teacher training (1) Educational games (1)
Communications (Technical)	12	Wireless technologies (3) Mobile phones (2) DTN (2) Disaster prevention and relief (1) Telecommunications (2) Satellites (1) Security (1)
Communications (Social Sciences)	17	Telecenters (general) (8) Low-cost computers (4) Radio (2) Disaster prevention and relief (1)
Governance	5	Telecenters (governance) (4) Digitized Records (1)
Healthcare	2	Medical education (2) User interfaces (2)
Design	15	General User-centered design (3) Input devices (3) Illiteracy (2) Voice recognition (2) Accessibility (2) Translation (2) Graphic interfaces (1)
Stakeholders / Business of ICTD	15	ICTD Business models (4) Microfinance (3) Kiosks (2) Models for ICT deployment (2) Supply chains (1) Social entrepreneurs (1) Mobile phones (1) Mobile phone commerce (1)
General ICTD	5	Methodology (3) Gender Empowerment (2)

A look at these raises back the issue of the multi-disciplinary nature of ICTD. While the diverse nature of our respondent profile is in itself an indicator of the range of scholarly traditions involved in ICTD work, it is not clear how much actual inter-disciplinary work is being done, and if so, what is the exact nature of such collaborations. Within engineering, there is comparatively much greater interest in ICTD from computer scientists, and this may be an outcome of the nature of much ICTD research or that several of the key leading faculty members and senior researchers in ICTD are from a computer science background. We also find that most publishing in ICTD even if interdisciplinary is usually restricted to being either engineering oriented or in the social sciences. Perhaps the most notable exception overall is design, which as a field had already started incorporating ethnography and other methods from anthropology. In fact, 81% of respondents stated that ICTD itself as a field had helped bring multidisciplinary research to greater focus in academia as a whole. Although most experts tended to agree that the multidisciplinary nature of work was a good thing, one concern raised by multiple participants was that of creating scholarly tenure track positions in ICTD. Although information schools have been early in recognizing the importance of ICTD, the case for ICTD is yet to be made for much of social science and engineering disciplines. A final, concerning thought came in reference to the issue of rigor in ICTD research. When asked if the existing ICTD research had been methodologically rigorous, less than a fifth of our respondents said yes, almost half the respondents felt the work thus far hasn't been rigorous enough.

VI. CONCLUSION

ICTD has made strides since the 1990s, both the expanding pool of people: researchers, industry and state partners, and high quality new work is evidence of this. What has also worked well for this growing field is that a lot of field projects and research are now closer to maturity, and that we see a lot less work on pilot projects and a lot more work reporting on the progress of initiatives and ideas. A fairly large body of ICTD researchers have now been in the field long enough to think critically and retrospectively on progress in this work. We hope that this document will serve as another step in that introspection.

REFERENCES

1. Qvortrup, L., *The Nordic telecottages : Community teleservice centres for rural regions.* Telecommunications Policy, 1989. **13**(1): p. 59-68.
2. Saxenian, A.L., *Silicon Valley's New Immigrant Entrepreneurs*. 1999: Public Policy Institute of CA.
3. Vertovec, S., *Transnational Networks and Skilled Labour Migration.* COMPAS, Oxford, 2002.
4. Castells, M., *Rise of the Network Society.* 1996.
5. Negroponte, N., *Being Digital*. 1995, Cambridge, MA: MIT Press.
6. Bhatnagar, S.C. and M. Odedra, *Social implications of computers in developing countries*. 1992: New Delhi: Tata McGraw-Hill.
7. Howkins, J. and R.L. Valantin, *Development and the Information Age: Four Global Scenarios for the Future of Information and Communication Technology*. 1997: IDRC (International Development Research Centre).
8. Roche, E.M. and M.J. Blaine, *Information technology, development and policy.* Information Technology, Development and Policy, EM Roche & MJ Blaine (eds.). Avebury: Aldershot, UK, 1996.
9. Heeks, R., *Technology and Developing Countries: Practical Applications, Theoretical Issues*. 1995: Frank Cass & Co.
10. Madon, S., *Information-Based Global Economy and Socioeconomic Development: The Case of Bangalore.* The Information Society, 1997. **13**(3): p. 227-244.
11. Hanna, N., *Exploiting information technology for development: a case study of India*. 1994: The World Bank.

12. Nulens, G. and L. Van Audenhove, *An Information Society in Africa?: An Analysis of the Information Society Policy of the World Bank, ITU and ECA.* International Communication Gazette, 1999. **61**(6): p. 451.
13. Wehn, U. and R. Mansell, *Knowledge societies*. 1998: Published for and on behalf of the United Nations by Oxford University Press New York.
14. Oestmann, S. and A.C. Dymond, *Telecenters - Experiences, Lessons and Trends*, in *Telecenters: Case Studies and Key Issues*. 2001, Commonwealth of Learning: Vancouver. p. 1-19.
15. Brewer, E., et al., *The case for technology in developing regions.* Computer, 2005. **38**(6): p. 25-38.
16. Subramanian, L., et al., *Rethinking Wireless for the Developing World.* Proc. of the 5th Workshop on Hot Topics in Networks (HotNets), November, 2006.
17. Seth, A., et al., *Low-cost communication for rural internet kiosks using mechanical backhaul.* Proceedings of the 12th annual international conference on Mobile computing and networking, 2006: p. 334-345.
18. Raman, B. and K. Chebrolu, *Experiences in using WiFi for Rural Internet in India.* IEEE Communications Magazine, 2007. **45**(1): p. 104–110.
19. Jhunjhunwala, A., *Unleashing Telecom and Internet in India.* India Telecom Conference at the Asia/Pacific Research Center, Stanford University, November, 2000.
20. Hoffman, D.L. and T.P. Novak, *Bridging the Racial Divide on the Internet.* Science, 1998. **280**(5362): p. 390-91.
21. Compaine, B.M., *The Digital Divide: Facing a Crisis Or Creating a Myth?* 2001: MIT Press.
22. Hendry, J.D., *Social inclusion and the information poor.* Library Review, 2000. **49**(7): p. 331-336.
23. Warschauer, M., *Reconceptualizing the Digital Divide.* First Monday, 2002. **7**(7): p. 0-262.
24. Singh, N., *Information Technology as an Engine of Broad-Based Growth in India*, in *The Future of India and Indian Business*, P. Banerjee and F. Richter, Editors. 2002, Macmillan: London.
25. Heeks, R., *India's software industry*. 1996: Sage Publications Thousand Oaks, Calif.
26. Arora, A., et al., *The Indian software services industry.* Research Policy, 2001. **30**(8): p. 1267-1287.
27. Saxenian, A.L. *Bangalore: The Silicon Valley of Asia?* in *Conference on Indian Economic Prospects: Advancing Policy Reform,*. 2000. Stanford, California: Center for Research on Economic Development and Policy Reform.
28. Jhunjhunwala, A., *Can Telecom and IT be for the Disadvantaged?* Rural Development, 1998. **17**(2): p. 321–37.
29. James, J., *Low-cost computing and related ways of overcoming the global digital divide.* Journal of Information Science, 2001. **27**(6): p. 385-392.
30. Heeks, R., *Information Systems and Developing Countries: Failure, Success, and Local Improvisations.* The Information Society, 2002. **18**(2): p. 101-112.
31. Keniston, K., *Grassroots ICT Projects in India: Some Preliminary Hypotheses.* ASCI Journal of Management, 2002. **31**(1).
32. Madon, S., *Evaluating the Developmental Impact of e-Governance Initiatives: An Exploratory Framework.* EJISDC, 2004. **20**(5): p. 1-13.
33. Donner, J., *The Use of Mobile Phones by Microentrepreneurs in Kigali, Rwanda: Changes to Social and Business Networks.* Information Technologies and International Development, 2007. **3**(2): p. 3-19.
34. Heeks, R., *ICT4D 2.0: The Next Phase of Applying ICT for International Development.* COMPUTER, 2008: p. 26-33.
35. Thomas, P., *Bhoomi, Gyan Ganga, e-governance and the right to information: ICTs and development in India.* Telematics and Informatics, 2008.
36. Antin, J. *Cultural Assessment for Sustainable Kiosk Projects*. in *Information and Communication Technologies and Development, 2006. ICTD '06.* 2006.
37. Keniston, K., *IT for the Masses: Hope or Hype.* Massachusetts Institute of Technology (MIT), Cambridge, MA, 2003.
38. Perednia, D.A., *Telemedicine technology and clinical applications.* JAMA, the journal of the American Medical Association, 1995. **273**(6): p. 483-488.
39. Chandrasekhar, C.P. and J. Ghosh, *Information and communication technologies and health in low income countries: the potential and the constraints.* Bulletin of the World Health Organization, 2001. **79**: p. 850-855.
40. Sahay, S., *Special Issue on "IT and Health Care in Developing Countries".* EJISDC, 2001. **5**: p. 0-1.
41. Brauchli, K., et al., *iPath-a Telemedicine Platform to Support Health Providers in Low Resource Settings.* Stud Health Technol Inform, 2005. **114**: p. 11-7.
42. Surana, S., et al., *Deploying a Rural Wireless Telemedicine System: Experiences in Sustainability.* COMPUTER, 2008: p. 48-56.
43. Ibrahim, M., et al. *Improving Healthcare Delivery in Developing Regions: Coupling Output-based Aid and Mobile Technologies*. 2007. University of California Big Ideas 2007 Conference.
44. Chandani, Y. and G. Breton, *Contraceptive Security, Information Flow and Local Adaptations: Family Planning in the Philippines and Morocco.* EJISDC, 2001. **5**(3): p. 1-18.
45. Luk, R., M. Ho, and P.M. Aoki, *Asynchronous remote medical consultation for Ghana*, in *Proceeding of the twenty-sixth annual SIGCHI conference on Human factors in computing systems*. 2008, ACM: Florence, Italy.
46. Ramamritham, K., et al., *Innovative ICT Tools for Information Provision in Agricultural Extension (December 2005)*. Information and Communication Technologies and Development, 2006. ICTD'06. International Conference on, 2006: p. 34-38.
47. Kaushik, P.D. and N. Singh, *Information Technology and Broad-Based Development: Preliminary Lessons from North India.* World Development, 2004. **32**(4): p. 591-607.
48. Salvador, T., J.W. Sherry, and A.E. Urrutia, *Less cyber, more cafe: Enhancing existing small businesses across the digital divide with ICTs.* Information Technology for Development, 2005. **11**(1): p. 77-95.
49. Kumar, R., *eChoupals: A Study on the Financial Sustainability of Village Internet Centers in Rural Madhya Pradesh.* Information Technologies and International Development, 2004. **2**(1): p. 45-74.
50. Patel, N. and T. Parikh. *Designing a Farmer-centric Organic Certification System*. in *ACM SIGCHI 2008, Workshop on HCI for Community and International Development*. 2008. Florence, Italy.
51. Panchard, J., et al. *COMMON-Sense Net: Improved Water Management for Resource-Poor Farmers via Sensor Networks* in *Information and Communication Technologies and Development, 2006. ICTD '06.* 2006.
52. Heffernan, C., *The Livestock Guru: Demand-led knowledge transfer for poverty alleviation.* Information and Communication Technologies and Development, 2006. ICTD'06. International Conference on, 2006: p. 94-100.
53. Veeraraghavan, R., et al., *Kiosk Usage Measurement using a Software Logging Tool.* Information and Communication Technologies and Development, 2006. ICTD'06. International Conference on, 2006: p. 317-324.
54. Gandhi, R., et al. *Digital Green: A Participatory Digital Framework to Deliver Targeted Agricultural Information to Small and Marginal Farmers*. in *Second International Conference on Information Technologies and Development, Dec 2007, IEEE Conference Proceedings*. 2007. Bangalore.
55. Parikh, T., K. Ghosh, and A. Chavan, *Design studies for a financial management system for micro-credit groups in rural india.* Proceedings of the 2003 conference on Universal usability, 2003: p. 15-22.
56. Sathe, S.K. and U.B. Desai, *Cell Phone Based Microcredit Risk Assessment using Fuzzy Clustering.* Information and Communication Technologies and Development, 2006. ICTD'06. International Conference on, 2006: p. 233-242.
57. Ratan, A. and M. Gogineni. *Cost Realism in Deploying Technology for Development*. in *Confronting the Challenge of Technology for Development: Experiences from the BRICS*. 2008. University of Oxford.
58. Patra, R., Pal, J., Nedevschi, S., Plauche, M., Pawar, U. *Usage models of classroom computing in developing regions*. in *Second*

International Conference on Information Technologies and Development, Dec 2007, IEEE Conference Proceedings. 2007. Bangalore.

59. Pal, J., *Examining e-literacy Using Telecenters as Public Spending.* Second International Conference on Information Technologies and Development, Dec 2007, IEEE Conference Proceedings, 2007. **2**: p. 59-68.
60. Banerjee, A.V., et al., *Remedying Education: Evidence from Two Randomized Experiments in India*.* The Quarterly Journal of Economics, 2007. **122**(3): p. 1235-1264.
61. Pawar, U.e.a. *Multiple mice for retention tasks in disadvantaged schools*. in *Proceedings of the SIGCHI conference on Human factors in computing systems*. 2007. San Jose.
62. Kam, M., et al., *Localized iterative design for language learning in underdeveloped regions: the PACE framework.* Proceedings of the SIGCHI conference on Human factors in computing systems, 2007: p. 1097-1106.
63. Wang, R., et al., *The Digital StudyHall.* Computer Science Department, Princeton University, Tech. Rep. TR-723-05, 2005.
64. Feghali, T., M. Martin, and N. Sahyoun, *An exploratory case study of a Lebanese e-learning partnership model.* World Review of Science, Technology, and Sustainable Development, 2006. **3**(2): p. 137-151.
65. Colle, R.D., *Building ICT4D capacity in and by African universities.'* International Journal of Education and Development using ICT, 2005. **1**(1).
66. Islam, Y.M., et al., *Mobile Telephone Technology as a Distance Learning Tool*. 2005, ICEIS.
67. Librero, F., *Uses of the Cell Phone for Education in the Philippines and Mongolia.* Distance Education, 2007. **28**(2): p. 231-244.
68. Moraveji, N., U. Pawar, and T. Kim, *A Mouse on Each Desk: An Inexpensive Classroom Interaction Technique for Remote Teaching.* Microsoft Research Working Papers, 2006.
69. Howard, J., C. Simms, and E. Simanis, *What Works: n-Logue's Rural Connectivity Model.* A Digital Dividend Study by the World Resources Institute, 2001.
70. Mishra, S.M., et al., *Economic Analysis of Networking Technologies for Rural Developing Regions.* 1st Workshop on Internet and Network Economics, 2005.
71. Ramanathan, N., et al., *Designing Wireless Sensor Networks as a Shared Resource for Sustainable Development.* Information and Communication Technologies and Development, 2006.
72. Bhagwat, P., B. Raman, and D. Sanghi, *Turning 802.11 inside-out.* ACM SIGCOMM Computer Communication Review, 2004. **34**(1): p. 33-38.
73. Pentland, A.S., R. Fletcher, and A. Hasson, *DakNet: Rethinking Connectivity in Developing Nations.* 2004.
74. Zahedi, E., M.A.M. Ali, and M.J. Gangeh, *Design of a Web-based wireless mobile teleconsultation system witha remote control camera.* Engineering in Medicine and Biology Society, 2000. Proceedings of the 22nd Annual International Conference of the IEEE, 2000. **2**.
75. Seth, A., et al., *An Architecture for Tetherless Communication.* DTN Workshop, 2005.
76. Fall, K., *A delay-tolerant network architecture for challenged internets.* Proceedings of the 2003 conference on Applications, technologies, architectures, and protocols for computer communications, 2003: p. 27-34.
77. Wei, S.J., *Corruption in Economic Development: Beneficial Grease, Minor Annoyance, or Major Obstacle?*, in *World Bank Policy Research Working Paper No. 2048*. 1999, World Bank: Washington DC.
78. Backus, M., *E-governance in Developing Countries.* IICD Research Brief, 2001. **1**.
79. Hasan, S., *Introducing E-Government in Bangladesh: Problems and Prospects.* International Social Science Review, 2003. **78**(3-4): p. 111-126.
80. Kiran, G.R., *E-governance services through Telecentres-Role of Human Intermediary and issues of Trust.* Information and Communication Technologies and Development, 2006. ICTD'06, Conference Proceedings, 2006: p. 131-142.
81. Riley, C.G., *The changing role of the citizen in the e-governance and e-democracy e-democracy equation.* Commonwealth Centre for e-Governance, 2003.
82. De, R. and C. Sen, *The Complex Nature of e-Government Projects: A Case Study of Bhoomi, an Initiative in Karnataka, India.* Proceedings of Electronic Government, Third International Conference, Zaragoza, Spain, Aug-Sep, 2004: p. 556–557.
83. Okot-Uma, R.W., *Electronic Governance: Re-inventing Good Governance.* Commonwealth Secretariat, London, 2000.
84. Narayan, G. and A.N. Nerurkar, *Value-proposition of e-governance services: Bridging rural-urban digital divide in developing countries.* International Journal of Education and Development using ICT, 2006. **2**(3).
85. Benjamin, S., Bhuvaneshwari, R, Rajan, P. *'E-Titling' or an "Anti-Politics Machine" necessary to globalize Bangalore?* in *International Conference on Enhancing Land Registration and Cadastre for Economic Growth in India*. 2006. New Delhi: Centre for Science, Development and Media Studies (CSDMS).
86. Vasudevan, R., *Changed Governance or Computerized Governance? Computerized Property Transfer Processes in Tamil Nadu, India.* Information Technologies and International Development, 2007. **4**(1): p. 101-112.
87. Rodrigues-Filho, J. and N.P. Gomes, *e-Voting in Brazil: Exacerbating Alienation and the Digital Divide.* Proceedings of the 6th European Conference on e-Government.
88. Tongia, R. and E. Subrahmanian, *Information and Communications Technology for Development (ICT4D)¿ A Design Challenge?* Information and Communication Technologies and Development, 2006. ICTD'06. International Conference on, 2006: p. 243-255.
89. Chandru, V., et al. *The Simputer: Radical Simplicity for Universal Access*. in *Development by Design: ThinkCycle Open Collaborative Conference, Bangalore 2002*. 2001.
90. Harvey, F., *Computers for the Third World.* Scientific American, 2002.
91. Medhi, I., A. Sagar, and K. Toyama. *Text-Free User Interfaces for Illiterate and Semi-Literate Users*

in *Information and Communication Technologies and Development, 2006. ICTD '06. International Conference on*. 2006.

92. Plauché, M. and M. Prabaker, *Tamil market: a spoken dialog system for rural India.* Conference on Human Factors in Computing Systems, 2006: p. 1619-1624.
93. Sherwani, J., et al. *HealthLine: Speech-based Access to Health Information by Low-literate Users*. in *Second International Conference on Information Technologies and Development, Dec 2007, IEEE Conference Proceedings*. 2007.
94. DeRenzi, B., et al., *E-imci: improving pediatric health care in low-income countries.* 2008.
95. Ho, M. *Smartphones for Output-Based Aid*. in *ACM SIGCHI 2008, Workshop on HCI for Community and International Development*. 2008.
96. Kam, M., et al., *Practical considerations for participatory design with rural school children in underdeveloped regions: early reflections from the field.* Interaction Design And Children, 2006: p. 25-32.
97. Atkinson, A.B., *New Sources of Development Finance*. 2005: Oxford University Press.
98. Jenkins, R., *Globalization, Corporate Social Responsibility and poverty.* International Affairs, 2005. **81**(3): p. 525-540.
99. Fox, T., *Corporate Social Resposibility and Development: In quest of an agenda.* Development, 2004. **47**(4): p. 29-36.
100. Pal, J. *Computers and the Promise of Development: Aspiration, Neoliberalism and 'Technolity' in India's ICTD enterprise* in *Confronting the Challenge of Technology for Development: Experiences from the BRICS*. 2008. University of Oxford.
101. Kuriyan, R., K. Toyama, and I. Ray, *Integrating Social Development and Financial Sustainability: The Challenges of Rural Computer Kiosks in Kerala.* Information and Communication Technologies and Development, 2006. ICTD'06. International Conference on, 2006: p. 121-130.