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# Capable and convivial design (CCD): a framework for designing information and communication technologies for human development

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Scholarship and implementation in information and communication technologies for development (ICTD/ICT4D) have seen an exponential increase over the past decade. In spite of enormous headway in both research and application, ICTD lacks a clear unified framework that can guide contextually grounded user-focussed design of ICT. This shortcoming results largely from the field's unusual placement at the intersection of research, policy, and practice, each driven by different philosophical traditions and application intentions. We argue that this gap can be overcome by adopting design-based approaches in ICTD. Towards this end, we advance a design framework – capable and convivial design (CCD) – that appropriates Sen's idea of capabilities and Illich's notion of conviviality. We contend that these two sets of complementary theoretical traditions are markedly well suited to guide the design of contextually relevant and user empowering ICTs. We test the CCD framework against multiple input shared computing, a well-documented ICTD case, to illustrate its analytical usefulness and improve its analytical precision.

**Keywords:** capability; conviviality; development; freedom; design framework

## Introduction

The last decade has seen significant research and implementation efforts devoted to information and communications technologies (ICTs) with the intent of addressing problems of acute economic and social disparity. The primary field engaged with this work is popularly referred to as ICT for Development (ICTD/ICT4D). The field bears a distinctly multi-disciplinary flavor, bringing together researchers and practitioners from the social sciences, physical and natural sciences, engineering, and industry. The resulting work includes a rich mix of experimental innovation and incremental product development guided by diverse theoretical and philosophical perspectives and policy goals. Currently, most ICTD efforts are primarily framed in the theory and practice of development and empowerment. We argue here that while these have been important guiding perspectives that have helped keep ICTD work grounded in the social realities of its orientation, an important and missing foundation for ICTD work is *design theory*. Establishing a basis in design is essential if ICTD is to satisfy its purported goal of making a real difference in the lives of its intended beneficiaries – those that are significantly disadvantaged in terms of resources as well as opportunities. With this goal in mind, we propose a framework that leverages design-based approaches as the foundation for ICTD while maintaining the empowerment orientation of ICTD. This framework can assist the field

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in moving beyond a restricted focus on fulfilling basic needs or access and towards the goal of enriching users' lives. Our framework combines Sen's (1999) idea of capabilities, which argues for examining development from the perspective of creating functional pathways for the free exercise of opportunities, and Illich's (1973) concept of conviviality, which argues for empowering users to exercise agency over the design of tools and infrastructure intended for their use. The capabilities approach addresses the broader issue of how development initiatives ought to empower users starting from the existing capabilities, aspirations, and needs of the users. The conviviality approach looks at opening up the design practice to the user such that the artifacts intended for their use are created not just with their latent input but with their very active participation in conceptual process. The underlying theory of letting the users "take charge" of their own development or design brings together the conviviality and capabilities approaches.

In the rest of the paper, we first make the case for a design-based approach to ICTD and the importance of a design framework and then argue that an approach that combines the idea of capabilities and conviviality is very well aligned philosophically with both traditions and is uniquely able to bring together the seemingly disparate fields of design thinking and human development. We then distill four guidelines that synthesize Sen's and Illich's work and make their ideas tangible for design: accessibility and availability of artifacts, ability for self-expression and creativity, ability to interact and form relationships, and ability to reciprocate by contributing back to the environment. Finally, using the case of shared concurrent computer use through multiple input devices, frequently referred to as "multiple mice" (MM) a very successful and much discussed project in the ICTD space, we illustrate how our framework can offer an ecological basis for design by foregrounding the situated practices of users in their everyday life. We selected MM among other possible cases given the maturity reached by the research and subsequent product development. The nature of involvement of the authors with the project, discussed in detail later, further motivated the selection of the MM case due to our familiarity with the case. We apply our framework retrospectively to the MM case with aim to test the analytical power of the framework and increase it analytical precision and not to argue that MM was a case of capable and convivial design (CCD). Our framework, we argue, helps overcome a primary shortcoming of ICTD work – the acute disconnect between users and designers due their disparate context and the typical geographical distance between them.

## A design-based approach to ICTD

The design of new technologies for use in low-resource environments, often aimed at fostering social or economic development, has been growing as an area of interest among researchers and practitioners in both the development and ICT communities in the past decade (Bada & Madon, 2006; Heeks, 2008; Silva & Westrup, 2009). The intellectual reasons behind the growth of ICTD are varied with motivations from within the academic groups from development studies (Avgerou, 1998; Soete, 1985), information studies (Qureshi, 2005; Van Dijk, 2005), business and industrial development studies(Indjikian & Siegel, 2005; Prahalad, 2009), and policy (Cecchini & Scott, 2003; Grace et al., 2004), as well as in practice, where an increasing number of corporations including Hewlett Packard, Microsoft, Intel, and IBM invested in product development, Corporate Social Responsibility and research initiatives around ICTD (Lahiri & Pal, 2009; Preston, 2001). Brand and Schwittay (2006) designate the drivers of ICTD projects as the three axes of technological innovation, development programs or new market creation. Within engineering circles, two arguments have been foundational in framing the ICTD agenda. The first is that technologies originally designed for the infrastructural conditions are not ideally suited for developing regions, and that this in itself offers rich possibilities for new research in low-resource settings. The second argument is that the conditions of

underdevelopment represent much need for technological intervention for new efficiencies, and this in turn lays out a new research agenda that would typically find no market takers in the industrialized world – be it low-cost telephony, new speech-based technologies in less represented languages, or interfaces for non-literate users (Brewer et al., 2005). This argument, subsequently noted by a number of mainstream design and HCI scholars in the ICTD space (Parikh & Lazowska, 2006; Ramachandran, Kam, Chiu, Canny, & Frankel, 2007) is a foundational motivation for the development of our argument and framework.

The goal to develop ICTs that address the needs of end users in a contextually relevant manner implies that one of the imperatives is to understand that social, economic, and physical context where the ICT will be used. In other words, an effective approach for an ICTD project would necessitate a contextual inquiry approach at the very foundation of its design thought. Working in scenarios where the past experience with any form of technology can be limited, and innovations do not enter into a larger ecology of technological artifacts that serve as a support system for the new intervention, a deep understanding of the user cannot be overstated. This imperative gives credence to a focus on design and the usefulness of leveraging design-based approaches. Within the umbrella of design-based approaches are ideas and perspectives such as "design thinking," "design-based research," "design case studies;" numerous design-focussed frameworks in related fields such as "value-sensitive design (VSD)" and "value-centered design (VCD);" and, design methods such as "participatory design," "end-user design," "contextual design," and "scenario-based design." The design thinking approach argues for an iterative process that "empathizes" with the user and wherein the user's experiences framed within the "solution offered" by the technological intervention are the starting point. Frequently, the struggle for designers is that despite their intention to follow the idealized scenario where a technology is completely conceptualized bottom up in line with a user's needs, the reality of market driven product focused design has to take precedence.

User-centered design approaches lay out in detail how the actual process of design should proceed including techniques such as brainstorming and the use of prototypes. The design-based research (Design-Based Research Collective, 2003) perspective emphasizes the empirical aspects of the design process where research and design are intertwined and different implementations of design ideas in actual settings are essential to empirically understand which approach works and which does not. The primary takeaway here is that design can form the basis for empirical evidence and is not orthogonal to research. The design case studies approach (Wulf, Rohde, Pipek, & Stevens, 2011) provides guidelines on developing an entire research program around the design and development of ICT with the objective of developing case studies of design that can provide lessons through comparisons. The VSD (Friedman & Kahn, 2003) approach provides an overarching framework – empirical as well as implementation – to design ICT that reflects moral and ethical values such as privacy, etc. The VCD (Cockton, 2005) approach argues for designing ICT that can provide a normative value to the user, that is, there is value-add. Participatory design (Muller & Kuhn, 1993) and end-user development (Lieberman, Paterno, Klann, & Wulf, 2006) emphasize the inclusion of the user in the design process and the tailorability of the design artifact. Contextual design (Beyer & Holtzblatt, 1998), a popular approach for user interface and system design, outlines how to account for context. Scenario-based design (Carroll, 2000) is a specific mechanism that outlines how user scenarios of use are critical for useful and usable design. Each of these perspectives has something useful to offer to ICTD and even though these approaches are motivated primarily, though not exclusively, by non-ICTD contexts, they can be appropriated for ICTD work and several ICTD scholars have done so (Kam, Ramachandran, Devanathan, Tewari, & Canny, 2007; Ramachandran et al., 2007).

In spite of their relevance and application in ICTD, the approaches identified above lack a strong basis in human development and empowerment, issues that are critical to ICTD. It is

with this goal in mind that we forward an overarching framework that can serve as a basis for inclusive design that hands over control to the user. The use of the framework in ICTD will allow designers to bridge the gap that exists between them and intended users and provide a more relevant guidance as compared to other approaches. In that sense, the framework we propose is receptive to and can encompass other related approaches.

In developing this framework we were motivated by some important considerations. First, we were cognizant that given the extremely relative nature of social and economic development in different geographies, arrival at a single set of design principles is challenging, and a useful framework must apply across contextual variations. Therefore, a design framework must encapsulate broad principles that are useful and effective but at the same time it must respect design diversity. Second, design frameworks also serve the added benefit of being boundary objects that allow interdisciplinary researchers to coalesce around a research topic or field. This value is particularly relevant in the context of new and/or emerging research areas such as ICTD (Best, 2010). In particular, the computing field has become interested in ICTD and has been prolific in addressing ICTD issues leading to a special interest group on the topic within the Association for Computing Machinery. But these developments have also led to guarded criticism that the field is in danger of fragmentation since the attempts are many but are guided by different theoretical and pragmatic leanings.

It is in this sense that we believe that an overarching framework, although hard to develop, can serve as a boundary object to allow different interested parties to work together while preserving their unique identities. A third goal we wanted to target in our design framework was to serve both a pragmatic and inspirational purpose – to help guide the design process (how to design) but also provide an overarching framework to establish need for design (what and why of design). We believe this complementarity is critical for user empowering design as it is essential not to lose focus of the overarching goal while designing as well as not be focussed on design details. Finally, we targeted our framework to help address one of the most severe shortcomings of ICTD work – discussed in-depth below – which is to guide new technology development that goes beyond basic access and needs and provide a more comprehensive approach that balances needs with imagination.

## Beyond needs and access: capabilities and conviviality as the basis for ICTD

A core concern that has emerged among ICTD scholars over the last few years is a disproportionate emphasis in current ICTD discourse on fulfilling basic needs of users in low-resource environments without adequate attention to user-motivated concerns addressing which would enrich their lives rather than merely provide access and satisfy basic needs. In particular, scholars argue, there is a need to design ICTs that actually impacts human development by empowering the users to help themselves (Liang, 2010; Norris, 2001) and by making judicious use of resources that already exist (Gurstein, 2003; Warschauer, 2002). For instance, Gurstein (2003) argues that for effective use of ICTs it is important that users have the capacity and as well as the opportunity to successfully integrate ICTs into the accomplishment of self or collective goals. In a similar vein, Warschauer (2002) argues that a divide is created when users have physical access to ICTs without having the additional resources that would allow them to use that technology well. He forwards the notion of "social inclusion" to convey that not only should the user participate in determining the use of resources but that they should also be able to participate even when they lack an equal share of resources. This kind of integration can be achieved only if designers redirect their focus from ICT for an individual user or even a user within a context, or user as a social actor view, towards "user as collective," where, to even begin to understand

the user, we need to examine the collective formed out of others and of the context in which the user is embedded (Lamb & Kling, 2003).

This call for redirecting ICTD to move beyond a focus on needs and access is refreshing, but for empowering design we need to go beyond this. We need to understand and integrate the reciprocity that exists among different elements in the ICTD environment and leverage this relationship to allow users to be expressive and creative. Overall, as use and implementation of ICTs proliferate, a question emerges: How can we frame ICTD work to bridge the gap between designers and users to produce tools that make user empowerment tangible? We believe that the answer to the question lies in a design framework that leverages the ideas of two remarkable scholars, Sen (1999) and Illich (1973). Sen argues that the primary end and principal means for achieving human development is individual freedom and Illich's idea of conviviality broadly refers to power and control of individuals over the range of physical and metaphorical tools they possess as part of their social and economic being and use of those tools for self-expression. In essence, they both emphasize user empowerment and personal freedom as the means to advance human development thereby providing an avenue for moving beyond needs and access and towards the enrichment of users' lives.

### *Capabilities*

In his 1999 book *Development as freedom*, Amartya Sen argues that the primary end and principal means for achieving human development is individual freedom. This individual freedom is a "social product" which emerges from a two-way relationship between social arrangements that expand individual freedoms and the use of these freedoms by individuals to improve their respective lives and also to make "social arrangements more appropriate and effective (Sen, 1999, p. 31)." He argues that freedom should exist irrespective of whether an individual acts on these freedoms or not. He goes on to outline five "instrumental" freedoms: economic opportunities, political freedoms, social facilities, transparency guarantees, and protective security.

Furthermore, Sen recognizes the multifaceted nature of the concept of freedom as development and argues against a universal evaluative concept to determine whether development has taken place. For him heterogeneity of factors is a pervasive reality and the assumption that a single homogeneous aspect, such as income or utility, can capture personal circumstances only evades the real problem of assessment. Therefore, he argues, it is imperative that within any framework or concept there is leeway to take different variations into account. This variation, he argues, can be accounted for by evaluating freedom along two dimensions: (1) *Functionings*, which reflect the various things that a person may value doing or being, and (2) *Capabilities*, which refers to the alternative combinations of functionings that are feasible for her to achieve. Capability itself is thus a kind of freedom, "the substantive freedom to achieve alternative functioning combinations (or, less formally put, the freedom to achieve various lifestyles) (Sen 1999, p. 75)." We adopt this core idea within the framework that we propose by making "expansion of capabilities" (see Zheng, 2009; Alkire, 2005 for an extensive discussion) a central piece of our framework.

The capability approach states that users should have the opportunity to actively engage in self-chosen acts of use and should have the fundamental freedom to help themselves. Therefore, a core outcome of ICTD has to be the support for allowing users to lead the kind of lives they value and have a reason to value. Not surprisingly, a large extent of ideas can be covered under the capability argument. Even from a commonsense point of view, as Oosterlaken (2009) argues, the capability approach appears to be strongly compatible with the use of technology since one of the primary functions of technology is, or should be, increasing the capabilities of users (p. 94). The capabilities approach is finding acceptability in ICTD (Qureshi, 2011) and in his

discussion of the role of capability, Oosterlaken (2009) outlines how the capability perspective can strengthen design of ICTD. He argues that to improve the applicability of the approach to ICTD, specific capabilities and interventions should be synthesized and tried and more design case studies should be produced. Towards this goal, we next appropriate Illich's (1973) idea of conviviality so that we can concretize some core ideas for ICT design – What are some critical elements of capabilities that a designed ICT can and should support?

### *Conviviality*

The second critical theoretical position we appropriate in order to concretize ideas adopted from Sen is Illich's (1973) concept of conviviality. Illich's work, done in early 1970s, was as a disjuncture from the discourse that took the industrial mode of production and consumption as the status quo of human life and suggested an alternative – which he termed conviviality – and that is to give more power to individuals to be able to exercise their freedom of expression. Illich (1973) chose the term "conviviality" to convey "autonomous and creative intercourse among persons, and the intercourse of persons with their environments; and this in contrast with the conditioned response of persons to the demands made upon them by others, and by a man-made environment (p. 11)."

Illich (1973) considered conviviality to be an intrinsic ethical value of individual freedom realized in personal interdependence. Furthermore, he was of the strong belief that in any society, "as conviviality is reduced below a certain level, no amount of industrial productivity can effectively satisfy the needs it creates among society's members (p. 11)." Overall, Illich's notion of conviviality envisions that people will be able to enjoy their individual freedom, contribute to the world in which they live, be able to take care of themselves without relying too much on people in power and on artifacts, and generally, be creative and innovative.

Of particular relevance to design, Illich (1973) directly addressed the idea of built environments – social as well as artifactual – under the term "convivial tools." He was averse to artifacts and designed or engineered environments that took freedom away from individuals and led to what he thought of as their exploitation. He argued that, "A convivial society should be designed to allow all its members the most autonomous action by means of tools least controlled by others … the growth of tools beyond a certain point increases regimentation, dependence, exploitation, and impotence (p. 21)." Illich also expressed a need to create environments that were intrinsically motivating, that brought people joy and not mere pleasure, and that drove people to express themselves without any forced conditions.

For Illich (1973), the idea of control and power was central to his thesis of a convivial society and the shift in control brought about in human labor due to the rise of industrial society led to his dissatisfaction with the status quo. As an example of the abuse of tools Illich cites the rise of the medical profession. He argues that medicine as a force has continuously taken the power away from the people, people it purports to cure, and institutionalized the process of healthcare, making it increasingly harder for people to care for themselves and turn ever more reliant on "trained" medical professional. He laments this change in the name of "progress" when, he argues, most of the common illnesses can be diagnosed by people who need little or no training leaving the highly trained people to focus their skills and efforts towards patients who need critical care.

## A framework for CCD in ICTD

From Sen's discussion of capabilities, functionings, and types of freedoms we generate four core ideas that we believe can be and should be addressed by ICTD. This is, of course, our reading

and interpretation of his work. These four ideas are: (1) *Accessibility*, within which we include the ability to access an artifact and through the use of that artifact access information which is of value to the user; (2) *Creativity/Intensification*, is a dimension that focusses on the actual use of the artifact beyond just access to it for means that give the user joy and allow the users to express themselves in a creative manner; (3) *Accomplishment of Self/Others*, under which we address issues of self-respect, gender relations, power dynamics, and other context dependent relationships; and, (4) *Participation/Collectivity*, which brings to the fore issues of a participative culture and working in a collective milieu. Our primary purpose in delineating these four issues was to be able to use them as a pathway into interpreting Illich's work in order to outline a framework. Overall, Illich's idea of conviviality not only strongly complements Sen's notion of capabilities but also provides a way to reconcile the individual-oriented nature of Sen's work with institutional structures in a more pragmatic manner. This makes the contribution of both ideas more meaningful for a design framework that targets an environment where the social context often creates a significant collective, and in turn, personal motivation (Konkka, 2003). In accordance with Sen's principles of capabilities – respecting the values users think are important to them – and conviviality – giving users more power – we have synthesized four primary characteristics that design of ICTD should target in accordance with the CCD framework:

1. Access to artifacts (accessibility easiness)
2. Ability for self-expression (expressive creativity)
   a. Ability to use personal energy creatively
   b. Ability to personalize the environment
3. Ability to interact and form relationships with other people (relational interactivity)
4. Opportunity to enrich the environment (ecological reciprocity)

Together, the characteristics outlined above enhance a person's self-image as a tool is used and make it possible for him to "invest the world with his meaning;" in other words, capable and convivial tools allow engagement with self, others, and the environment in a symbiotic manner. Of these four characteristics, access to artifacts means artifacts are universally accessible and that the ability of one person to be able to use the tool should not take away the opportunity from another person. In a manner, the CCD framework argues for equitable distribution of resources. The second concept, self-expression, captures the idea that people should have the freedom to express themselves such that they are able to use their effort in a creative manner and also be able to modify the environment or the tool in a manner that is personally useful and satisfying. This element is present in many of the new web-based computing artifacts that are available today as we discuss below.

The relational component of the framework stems from the focus of capability and conviviality on the social aspects of human life and the ability and need for people to form ties with other people. People should be able to develop and maintain associations with others to share ideas and this augments their creativity. This is the backbone to producing and sustaining a society that values individual freedoms. The ecology component highlights the need for people to give back to their environment and not just take resources from it. In a way, people form a relationship with the environment they live in, in such a way that each privileges and benefits the other. Given the current focus and awareness of environmental issues, this characteristic becomes particularly relevant as we design new artifacts.

When considered in tandem, these four characteristics complement and extend current design traditions discussed above, such as contextual and participatory design, and provide tangibility to ideas such as empowered design (Marsden, 2008) and stakeholder engagement (Ramirez, 2007). Furthermore, the CCD approach goes beyond other design-based approaches

by making user expressivity central to development efforts and by highlighting that contextual and institutional considerations are central to development efforts. And although our design framework is neutral on the nature of empiricism, it encapsulates it and allows leveraging other perspectives such as "design thinking" and "design-based research" that already exist. It also allows designers to work within the traditions of other approaches such as user-centered design and participatory design. Unlike a framework such as VSD, we deliberately do not make CCD more predictive or narrow as we believe that broad ideas that guide design – whatever the exact design method is adopted – is a better strategy. Finally, the CCD framework brings both the design of the artifact as well as its implementation and its consequences for the redesign of the artifact with the purview of the overall design process.

## MM: A case study in CCD

In this section we use a case study that illustrates the analytical potency of the CCD framework. We appropriate the case of shared concurrent computer use through multiple input devices, frequently referred to as MM. We chose MM among other possible cases since this project has reached a maturity which is quite uncommon among ICTD projects not only in research but also in product development. The work of one of the authors of this paper, while at the Microsoft Research, found that the single defining factor about computer use among children in poor schools of India was that the software was designed for single user scenarios, whereas invariably, the computers would be shared by a number of children. Based on this research, Microsoft Research would go on to innovate with MM on computers that allowed for several children to work on a single computing screen with each child using his or her own input device. Over two years, there was much research into MM with over 20 major publications on the original system and its variants as the design went through iterations, much of the work done by members of the original team working on the design and their subsequent collaborators.

While the project was not initially undertaken based on CCD principles, experience with the designers working on the project indicates the importance of contextual inquiry in the various design decisions, and the critical role played by the users of the technology in the direction various newer design iterations make it resemble very closely the ideals of Illich and Sen alike. The success with both user uptake and productization of the case study discussed suggests that the CCD ethic holds important lessons for future design in this space.

In the case of projects in the ICTD space, there is a significant risk of design processes that completely exclude the user, especially when such users are low-income, have low formal training or experience with using technology, or are physically distant from the design process. Children's sharing of computer resources in the developing world bears an ironic resonance to the idea in conviviality of the "distribution of unprecedented power." In their study of how computers were used in "digital divide" scenarios, i.e. low-income neighborhoods where a one-computer-per-child ratio was economically impossible to come by, researchers at Microsoft Research found that in any random group of children banding together to share a machine, the comparatively more affluent child tended to control the mouse, and that this control solidified over time (Pal, Pawar, Brewer, & Toyama, 2006). The researchers found that while "alpha" children tended to continue being the input controllers, the children who sat by their side had very little control over the screen resources and over time were comparatively less exposed to the screen content. Furthermore, the scarcity of computer resources meant that children had to huddle in small groups and use computers for digital curricular material for short sessions of 30 min or less, before rotating to the next group, thereafter often waiting up to a week for the next touch of the mouse. The pace of learning in any digital content would be managed by the mouse controller alone, and peripheral children rarely objected to material moving faster

than they could grasp, because a sense of pride over the ability to use the computers crept in, making the "pace dissenter" that slowed down the interaction an impediment to the collaborative computer-use session. A key finding from the research that informed the group's design decision was that while practically every instance of computer use among children in the developing world they observed featured many children huddled around a single PC (Figure 1), every piece of software they saw used was designed for a single user (Pal et al., 2006).

A group of researchers from Microsoft Research, UC Berkeley, and an Indian NGO specializing in primary education, called Azim Premji Foundation, worked with children and school administration for over a year, first attempting non-technical interventions such as teacher-motivated seating assignment in groups of children working simultaneously, and force-rotating the children to look at the impacts of removing the alpha child from controlling the pace of technology use. While such methods seemed to work in the short-run, the control over the physical technological artifact within groups of children, in this case the mouse, continued to be contested and hard to police by teachers. After toying with several design ideas including multiple keyboards and push-buttons, researchers, led by Microsoft Research Labs India's "Technology and Emerging Markets" group, settled on the idea of testing MM (Pawar, Pal, Gupta, & Toyama, 2007). The first year of work on MM was spent in iterations of designs with children to test the intuitiveness of the new usage modality, thereafter using the dynamics of learning in various MM scenarios to modify the screen and interaction designs (Figure 2).

The methodical and incremental approach of the researchers in the MM project is a good example of CCD, since the researchers went into the project without much of an idea of whether any technological intervention was needed. The researchers first attempted non-technical interventions, thereafter designed MM. However, from the CCD perspective, the design iterations with MM are most interesting. In their first published study, the researchers found that engagement among children increased after they each had their own mouse. In the subsequent study, following more tests with children, they found that while overall learning did increase, there was a trade-off between the increased engagement and collaboration, the latter being shown as the key in learning gains. Children, especially boys, were hampered in learning by increased competitiveness brought about by each child having his or her own mouse. This led the designers to develop further design iterations with switching mouse assignments, and split screens which featured a screen design in which children needed to collaborate within their own half, but would compete with children in the other half of the screen – thus using the

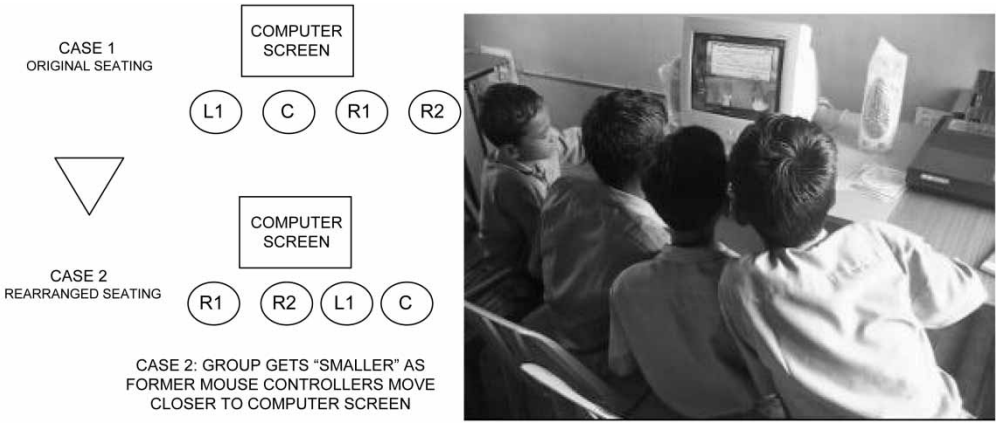


Figure 1. Initial study results showed that children display patterns in seating and mouse control.


Figure 2. MM – multiple input device and split screens lead to better learning than single input.

increased engagement and competitiveness to encourage the collaboration that furthered learning. Subsequent work in MM, mostly conducted on-site in India with users in low-income schools, created split screen learning interfaces for math learning, with numeric keypads instead of mice, to build on a past finding that numeric entry was important for children's learning, and findings from the past work that intelligent systems could be helpful in raising learning in groups with different learning speeds. Although there was a significant presence of US-based academics in some of the design, almost all of the early development was done by a Microsoft research team based in India, which was designed based on user research from local students. The technology in this case was transferred back from India to the USA. Microsoft itself created a product group in this space, looking at various modality of multiple input-based systems – including dumb terminal servers and classroom projection systems. Outside of India, experiments on MM systems worked with large user groups in China, and Chile, while real-world implementations of multiple input systems began in Thailand and Vietnam.

The MM project serves as a unique case to illustrate the analytical power of the CCD framework at multiple levels and improve its analytical precision. First, the idea is itself interesting from the CCD perspective because it employed the understanding of user needs to break away from the single-client model of technology (famously used in the One Laptop Per Child project, another project aimed at children in developing regions, but arguably designed with a comparatively more top-down design intention). Second, and more importantly, the MM team had no idea on what the end device or technology artifact would be like during early stages of research. Thus the research process empowered the users to fundamentally influence the form factor of what was being designed, as opposed to a more typical scenario where an already designed device is tweaked to suit needs. Finally, looking further through the design iterations, we see that principles of CCD have been critical through the design evolution because of the centrality of children in real-world scenarios through the process and the use of their on-screen power dynamics in design modifications. The success of MM speaks to larger concerns raised in relation to development pertaining such as conceiving of access as a technical issue without understanding the larger socio-political context which determines actual use (Gurstein, 2003). MM shows that although access is often an entry point into introducing technology, real design challenges lie in making improvements subsequent to access, even if the changes are small (see Table 1). As Kumar and Best (2006) note, technology, for instance, in the form of telecenters, can be beneficial if designed and implemented with certain affordances in mind which in their case was proximity to the community they are meant to serve and availability of local champions.

Table 1. CCD principles applied in MM case study.

| CCD principles | MM case study |
|---|---|
| Accessibility easiness | Accessible by more than one person at the same time; sharing with others |
| Expressive creativity | Being able to produce and use personal energy creativity to learn and solve problems |
| Relational interactivity | Learning with others in and through interaction; formation of relationships with others |
| Ecological reciprocity | Being able to teach others and enrich the learning environment; overall creation of learning practices |

## Discussion

Real dangers lurk around the corner in the race to digitize the world (James, 2008), especially in developing regions (Kuriyan, Ray, & Toyama, 2008). To leverage advances in ICT in an appropriate manner we need new ways to think about the relationship between computing and people. In this paper we advance a design framework – CCD – that can help achieve this objective by leveraging the ideas of capabilities (Sen, 1999) and conviviality (Illich, 1973). If closely followed, the basic principles of CCD, we believe, are likely to increase the feeling of freedom and equal participation among users. They are much more likely to lead to fulfilling relationships and engage people with their ability to allow them to reciprocate and contribute back to their environment. Moreover, we view our contribution in line with the idea of inspired design and designing for inspiration (Terrenghi, Harper, & Sellen, 2006) by being open to diversity, surprises, and reflection, with the aim of empowering users. In addition to the design of the artifact itself our design framework also argues for investment in the infrastructure around the artifact and might require additional time and/or monetary resources. As a matter of fact, Illich (1973) warns us that in lieu of symbiotic development of artifact and infrastructure – what he calls tool – the artifact becomes just another means for the powerful to dominate the powerless, meaning the people who do not have access or are not fluent in its use. User empowerment requires an increase in the diversity of the population that creates artifacts, increasing the chances that the tools will be designed for people that have been overlooked and by understanding what they value.

One of the contributions of our framework is that it operationalizes a spectrum of capabilities for the design of technology. An approach to functional ICTD work which operates within the frame of Sen's capabilities would be concerned with several of the high-level questions on if and how new technologies need to be designed – thus, from the hypothetical "top down" perspective of whether low-cost computers should be deployed as a developmental initiative would take into account a number of factors related to the users. These would include whether the computers themselves can be located within the broader exercise of freedoms by the intended users within their contextual setting – thus, the argument that "computers are good for learning" (if true) would have to be supported with whether the kind of "learning" in this case is prioritized in the same by the users, whether the need for the technological "solution" is in fact recognized and articulated by the intended users, and if not, then what explains these. The design and deployment process would thus either be an interactive reconciliation of "what can be built" with "what the intended user wants" or better still, a process where the idea for the technology comes from some bottom-up articulation of tools that are needed to fulfill intended freedoms.

The development of computing artifacts that follow CCD principles does not foreclose the possibility that designed artifacts will have unintended consequences. Irrespective of the goals of

its designer, artifacts neither convey a singular purpose nor are they solely appropriated for a singular purpose or even the purpose for which they are designed. In the same vein, ICTD designed for expressiveness might find relational uses. These issues though can be addressed by following a design-based research approach in conjunction with the CCD framework. Finally, a related and significant contribution of the framework is its flexibility in being applied in conjunction with other frameworks such as user-centered and participatory design approaches. The CCD framework in this scenario can serve as an overarching framing mechanism that reminds designers to ensure capability and conviviality – through the four principles – at different steps of the process.

As a criticism and limitation of our work it can be argued that our reading of Sen's and Illich's work is overly optimistic. Although we partly concur with this assessment we want to emphasize that it is a deliberate strategy on our part. Attempts to introduce technology in different ways have been a part of the development and engineering ethos for a while. From the introduction of dams that transformed agriculture to mobile phones that have transformed communication, technology is often omnipresent in all development efforts. We want to foreshadow the advantages that can accrue from amalgamation of the concepts of capabilities and conviviality when appropriated for design and analysis of computing artifacts and in particular, its ability to bridge technological deterministic and critical accounts of technology use (Kuriyan et al., 2008).

Deterministic accounts of technology have been criticized for their lack of attention to the context of technology use, especially "users" resistance to the technology. On the other hand, although critical accounts often provide a realistic analysis, they are prone to pessimism that highlights the shortcomings of a technology at the expense of its benefits. We argue that between these two diverse views there exists a middle ground where technology and people co-exist and have a reciprocal relationship that serves both stakeholders. This is where design is also particularly applicable as design directs us towards action. One of the purposes of this framework is to make both the artifact related and social aspects of ICTD equally explicit to bridge the divide between technological determinist and social determinist attempts. The framework can work as a boundary object and allow communities to communicate and collaborate. Although several of these technologies no doubt have used some design principles, many ICT for development do not have a specific set of design principles they follow. Therefore, we believe that in the context of such technologies the CCD principles will be uniquely advantageous.

## Conclusion

In this paper we advance a framework to help guide the design of user empowering and enriching ICTD. We draw on ideas forwarded by Sen (1999) and Illich (1973) to argue that ICTD should aim to enhance capabilities for individual freedom and do so in a convivial manner. We outline four particular aspects in which this framework can guide ICTD. This framework serves that purpose by reminding people that at the core of our work is an attempt to make the lives of people living in low-resource environments better and that this goal will be better accomplished if we go beyond fulfilling *needs* and work towards increasing imagination expressiveness. By doing so, we are likely to fulfill a need anyway but do a much better job at keeping the goals in sight. The framework also provides help in overcoming one critical failure of technology development which is to understand its design, implementation, and use in a larger context. One of the critical issues with engineering and computing efforts is a lack of understanding around societal and institutional issues that have to be taken into account in technology deployment. By recommending an ecological reciprocity attitude, the CCD framework makes that a

central aspect. We also hope that by making this debate mainstream we will be able to have a more inclusive dialog around design and innovation frameworks. The field is in danger of lapsing into "tinkering towards utopia" (Tyack & Cuban, 1995) where overall progress is little compared to the rhetoric that accompanies the work. Design is a political activity and often it is useful – such as in development efforts – to bring this front and center in the process. The ideas contained within the concepts of conviviality and capability further have an important lesson for the design of technological artifacts as they force designers to focus not just on improving interaction and usability but given attention to the need to for human self-expression with artifact use.

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