CHAPTER 1.10

Designing Technology for Inclusive Growth

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A couple of years ago ARM approached Inveneo, a United States–based information and communication technologies for development (ICT4D) nonprofit, to answer the question "What are the main challenges related to the deployment of technology hardware across the developing world?" By understanding the challenges, we believe that ARM and its business ecosystem can learn how to develop better products for this emerging market. Surprisingly, given the market size and the global interest in ICT4D, this study was the first research of its kind. The US Agency for International Development (USAID) was naturally interested in the topic and joined ARM in supporting the research, but it also fitted a wider USAID goal—that of encouraging the private sector to help tackle international development issues. This chapter looks at how both social and commercial benefits might be achieved by helping to include the developing world in the ICT revolution.

There are still 4.5 billion people without access to the Internet. Bain & Company, the global management consulting firm, suggests that this represents by far the largest opportunity of the next decade.[1] But the potential benefits go beyond commercial opportunity. There is now widespread agreement—along with emerging evidence—that ICTs can help improve quality of life and accelerate development efforts at all levels. Increased communications capabilities and access to information may be the most obvious advantages provided by ICTs. But nearly every aspect of development—including the meeting of basic needs—can be improved by the application of technology. In other words, ICTs hold tremendous potential to solve development challenges.[2]

Human factors, software, services, social influences, and many other ICT4D considerations have been studied repeatedly, but the impact of hardware has been largely ignored. This chapter's principal contribution is to address an overlooked, under-discussed—and therefore ill-addressed—feature of ICT4D: *the technology itself.* The lack of attention paid to the actual technology and the role it plays (or can play) in fostering inclusive growth and innovation has been detrimental to development-related outcomes, particularly because not paying attention to these elements results in the promotion—as opposed to the easing or eradicating—of inequality. If the needs, requirements, and realities present in the developing world are taken into consideration, ICTs that promote more inclusive growth is the result.

THE TOP FIVE ICT4D HARDWARE CHALLENGES

Based on in-depth interviews and a macro-level survey of experts, practitioners, academics, and end-users of ICT4D, Inveneo has identified the top five technology hardware challenges faced by the developing world:

1. **Electricity/power/energy.** The presence of low-power hardware with long battery life is crucial in an erratic power supply environment rife with electrical spikes, swings, dips, blackouts, and brownouts.

Box 1: Designing technology for international development

PROFESSOR GARI CLIFFORD, Oxford Centre for Affordable Health Technologies

When designing technology for international development programs and resource-constrained environments, many factors need to be considered alongside the development of the technology (both hardware and software) itself. Among these are:

- the needs of the target population—both the users of the tool and the population for which it is intended;
- the behaviors and cultural sensitivities of the same populations. Questions such as whether the technology will lead to an unintended consequence, for example, must be addressed;
- the availability of supplies and support infrastructure for the new technology;
- the hidden costs and risks of using the technology. For example, new procedures can add new costs for the recipient (e.g., travel costs or lost earnings);
- the training needed for the technology to be used properly;
- the cost of the technology (both in terms of initial outlay and ongoing maintenance costs) relative to alternatives, and the difference in potential impacts between the new technology and the alternatives;
- the existence of downstream facilities to deal with the output of the new technology. For example, it is no use being able to diagnose cancer if the population cannot afford or even locate treatment;
- the power requirements of the technology;
- the networked capability of the technology and the ease with which it can be monitored remotely by the program when necessary;
- post-sales support and the ability to perform recalls or update the technology;
- local regulatory mechanisms, competing products, and vested interests in retaining the status quo; and
- the ability for the technology to be self-sustaining and enable a business model to allow competitive use, without creating a monopoly or a concentration of power.

The above considerations require a multidisciplinary team of anthropologists, engineers, economists, and specialists (such as doctors). In particular, it is important for anthropologists to work in the field with the engineers to observe how the technology is used, and for the engineers to use the results in an agile development approach. This implies having multiple iterations of the product so its development adjusts according to the needs assessment and field trials.

2. **Cost.** Striking a balance between lowest cost and solid, reliable, functional technology is essential.
3. **Environment.** Products need to be designed with durability in mind, including resistance to water, humidity, dust, dirt, and extreme heat. Some screens are difficult to read in direct sunlight, so particular kinds of screens are needed (e-ink screens are ideal).
4. **Connectivity.** The more connected the network is, the more valuable it is. The main method advocated for connection is Wi-Fi.
5. **Maintenance and support.** Technology that cannot be locally maintained, supported, and repaired is not sustainable. Transportation for repair, maintenance, and support is expensive.

These hardware priorities should be put into the context of a much longer list of social factors to be considered. Unlike the hardware, however, these social factors benefit from a very large body of academic research.

Gari Clifford combines academic credentials with years of practical experience rolling out affordable health technology in developing countries. He has some insights into the social needs that must be combined with appropriately designed hardware if real benefits are to be achieved and sustained (Box 1).

The first decade of this century witnessed explosive growth in mobile phone adoption and diffusion across the continent of Africa, which previously had the lowest ICT penetration rate on earth. The ITU reports that this remarkable growth rate was twice that of the rest of the world.[3] Regarding developing countries generally, a 2012 report by Deloitte et al. found that a 10 percent expansion in mobile penetration leads to a 4.2 percent increase in Total Factor Productivity—which reflects a country's long-term economic dynamism.[4] Moreover, the success and the wide adoption of mobile banking in sub-Saharan Africa demonstrates that innovation can indeed germinate in, and diffuse from, developing world locations. M-PESA, the Safaricom m-banking platform in Kenya, now moves the equivalent of 43 percent of GDP annually.[5]

The issue of inequality is an important one. In their seminal article "The Economics of ICTs and Global Inequality," Heeks and Kenny (2002) put forth the argument that technology has been a force promoting inequality and divergence rather than equality and convergence. It is true that technologies that exacerbate inequality far outnumber those that ameliorate it. This need not necessarily be the case, however. But it will take a concerted, committed effort to ensure that the positive potential of technology is achieved.

Opportunities exist throughout emerging economies to deliver positive social impact, as identified by the

Digital Opportunity Task Force in 2000—and echoed countless times since:

> ICTs offer enormous opportunities to narrow social and economic inequalities and support local wealth creation, and thus help to achieve the broader development goals that the international community has set.[6]

This promise helps explain why many governments, development organizations—for-profit and nonprofit—and even individuals are attempting to harness the power of these enabling tools for inclusive development.[7]

A gap may still exist between theory and practice, however—both practitioners and scholars bemoan the contrast between ICTs' potential and their relatively modest measurable impact. Part of the answer may be that technology is obviously not the sole driver of inclusiveness. Recent UN and Organisation for Economic Co-operation and Development (OECD) publications have identified the need for well-designed and well-implemented social and economic policies to work alongside technology to promote innovation and inclusive development.[8] A targeted focus on STEM (science, technology, engineering, and mathematics)-related education is one example. Both the UN and the OECD emphasize the need for public and private sectors to join forces to address the challenges presented by the gap between theory and practice.

This theme has been taken up by the major international donors. The program Grand Challenges—a family of initiatives with partners that include USAID, the Bill & Melinda Gates Foundation, and the UK Department for International Development, among others—started as an attempt to spur innovation and private-sector engagement; an additional $50 million was committed to this program in October 2014 by the various partners. Their most notable Grand Challenge to date is the initiative Saving Lives at Birth. This initiative seeks to promote innovative technological and operational approaches across three childbirth-related areas: new scientific and technological approaches to prevent, detect, or treat maternal and newborn problems at the time of birth; service delivery models to provide high-quality care at the time of birth; and ideas for empowering and engaging pregnant women and their families to practice healthy behaviors and be aware of and access healthcare.

More than 4,000 innovators have responded to the initiative and over 135 innovators are currently receiving financial support that totals US$220 million. Ideas have come from all over the world—from an Argentinian auto mechanic, world-class scientists, and entrepreneurs to in-country nongovernmental organizations and established multimillion-dollar research institutions.

In 2014 a student team applied for funding from Saving Lives at Birth for their new nonprofit health technology organization, SimPrints, which awarded them a grant to launch a major pilot in Bangladesh (Box 2). SimPrints is interesting because it emerged from an understanding of a need in global healthcare, took an iterative approach to hardware development that could address this need, and had to discard many preconceptions as a result.

In contrast to the approach taken by SimPrints, almost all devices and innovations are targeted toward established markets peopled by literate users who already understand how ICTs can improve work- and lifestyle-related efficiencies. These users take for granted advanced electrical and connectivity infrastructures and are able to afford expensive technologies and utilize them in safe environments. They have also had a lifetime of exposure to ICTs and their evolution. This is not the case for people in the developing world, however, where even an "ON" button will not have the same immediate recognition as it does for someone in the developing world. When technologies developed for advanced markets are employed in poor, resource-constrained locations—where environmental conditions are harsh, electricity and connectivity are not assured, and technological literacy and understanding are scant—they fail.

When Literacy Bridge explored the idea of designing a mobile device specifically for the learning needs of the world's most vulnerable people, it began an iterative process of listening to user needs, understanding their environment, and proposing technology designs and revisions to those designs.

Cliff Schmidt, the founder and CEO of Literacy Bridge, comments:

> From our earliest research, we gained an initial understanding of the problem space: the world's poorest people are not able to make the most of their resources due to lack of access to learning new skills and healthier behaviors.
>
> Since the vast majority of the people we want to serve are illiterate, and live without access to electricity or mobile data networks, our answer was a technology called the Talking Book: a low-cost audio mobile device that didn't require literacy skills to operate, grid power, or mobile network access. The next step was to propose the idea of this device to hundreds of potential users to generate feedback and discussion that would lead to a more specific design or possibly a completely different one.[9]

Box 2: SimPrints: From hackathon to Saving Lives at Birth

TOBY NORMAN and **DAN STORISTEANU**,
Co-Founders of SimPrints

Driven by poverty and the promise of opportunity, the massive rural migration to Bangladesh's urban slums has created daunting challenges for community health workers like Nisita. Nisita is responsible for visiting almost 300 households a month in Korail, a major Dhaka slum. Many of her patients have similar names or names with multiple spellings, they might not know their exact date of birth, and most have no formal address. They lack any official form of identification. This "identification challenge" is exacerbated by migration within the slum, as up to 40 percent of the population move from one health worker's area to another every year, leaving old health records in limbo and forcing migrants to start over without any health history.

In 2013 the Humanitarian Centre in Cambridge, United Kingdom, hosted a "health hackathon" that brought together health workers in international development with technologists and entrepreneurs. One of the needs they described was the need to overcome the fact that a third of all children under five have no birth certificate and no health records. The team at SimPrints took on this challenge and has since developed a possible solution. We are working on a pocket-sized fingerprint scanner that instantly links an individual's fingerprint to his or her health records. The Bluetooth-enabled scanner allows health workers in the field to make better decisions by providing immediate and reliable access to critical medical information. A fingerprint is all it takes to find out, for instance, which vaccines someone has received and which remain to be administered.

Initially, we planned to build the system using readily available fingerprint scanners, but no single scanner was sufficiently durable, portable, accurate, and low-cost. But although the solution was evident—to build it ourselves—we did not want SimPrints to become yet another "outsider" solution. So we decided to get close to the challenges, listen to users and experts, and immerse ourselves in the context in which our system would be used.

Working in Bangladesh, it soon became clear that we needed to overhaul our design. Our prototype was a "swipe scanner" that requires people to swipe their finger across a sensor rather than hold it down on a "touch sensor." Yet we noticed that many fingers had stiffened with age, after years of manual labor, and found the swiping motion too difficult. Also, the groove on our scanner that guided a person's finger was not sufficient, and some people would swipe the wrong part of the scanner. It became obvious that a swipe scanner was not intuitive enough, requiring too much instruction from health workers to each of their beneficiaries. Though more expensive, a touch scanner was clearly essential. Had we focused on merely reducing cost, as is often the approach, we would never have developed a successful product.

Our user-centered approach was singled out by the judges of the Saving Lives at Birth Challenge to reduce maternal and newborn deaths. SimPrints won a major grant for its field trials, and in 2014 we began work with Johns Hopkins University's Global mHealth Initiative and BRAC, the world's biggest development nongovernmental organization. We hope Nisita will soon be able to identify all her patients quickly and accurately.

Literacy Bridge also spent time in the communities to observe how daily routines related to ways in which it might use the Talking Book device both directly and indirectly.

This cycle of observing, proposing, and soliciting feedback repeated several times over the course the design and development stage continues today. It allows the developers at Literacy Bridge to learn which features were critical and which were detrimental to user needs. For instance:

- A powerful loud speaker would enhance the ability for group meetings to incorporate the playback of instructional messages for group discussion.
- Adding a built-in microphone to the device created significant value to users while also providing a means for collecting ongoing feedback about the program.

In addition to understanding user needs, developers also learned critical information about the users' environment. For instance:

- Heavy rain and dust storms were common. The Talking Book would have to be especially durable and provide a seal over any electronic ports.
- Only basic carbon-zinc dry cell batteries were readily available, not alkaline batteries or those that use newer chemistries, which resulted in much lower performance characteristics. Understanding this meant designing the electronics very differently so that they would work using the batteries that were actually available.

Literacy Bridge started with the assumption that the right solution would not be with the first version. By approaching product design in stages, it avoided overinvesting in a device that had not yet passed the test of large-scale user adoption.

In partnership with UNICEF and ARM, 50,000 users are now testing the latest Talking Book design and Literacy Bridge is ready to invest in larger manufacturing scales to make the device the most cost-effective way to reach the world's most vulnerable communities with life-changing knowledge.

The Oxford Centre for Affordable Health Care (OxCAHT), SimPrints, Literacy Bridge, Inveneo, and USAID have all, independently, realized that technology can be much better designed to function well in the difficult conditions present across much of the developing world. For business, as much as for development organizations, this is where challenge meets opportunity.

To give an oft-cited example, it was the perceived potential competition inspired by the One Laptop Per Child (OLPC) program that spurred the netbook revolution,[10] and—arguably—the rebirth of the tablet market, as technology companies raced to meet a

Box 3: Five world-changing technology growth areas

ERICA KOCHI, Director and Co-Founder, UNICEF Innovation

UNICEF needs innovative solutions to some of the key barriers it faces—such as geographical remoteness of constituents, the limited infrastructure available in these areas, the slowness of data collection, and the lack of access for the most vulnerable populations to critical information and services.

UNICEF believes that the technology sector's expansion into emerging markets can deliver expanded profit alongside social impact. However, the big corporate players and mainstream technology industries are not yet seeing this as a core business opportunity.

As part of their new partnership, UNICEF's Innovation Unit and ARM have identified five technology growth areas that have the potential to benefit millions of people, especially children, around the world. Table A outlines these areas, as well as the need for further research and potential exploration of these opportunities.

Although all these areas are ripe for growth, challenges to adopting the technologies remain. These challenges may take the form of prohibitive cost, slow or lacking data usage and transmission, or maintaining consistent and reliable sources of power to keep devices charged. The private sector must play a key role in overcoming these obstacles. Investments must be made toward technology products and services designed specifically for the emerging markets they are trying to address.

Willingness to align the corporate agenda and social agenda in concert with unconventional partnerships in the space, such as the one developing between ARM and UNICEF, will generate the new conversations necessary to move the needle on both the business and the social sides.

Table A: Areas for technology growth

Emerging technology area	Growth opportunity
Mobile financial inclusion and services	The ability to send, save, and receive money easily is at the core of the global economy. However, 2.5 billion people—half the world's adult population—remain unbanked. Can existing and new financial institutions and technology companies bring the benefits of financial services to the most underserved? Can ubiquitous financial services solutions such as M-PESA also be applied to basic services such as healthcare and education?
Identity	The issue of identity—both formal and social—and a voice, access to essential services, authentication, privacy, security, and advertising are increasingly linked. But 230 million children (one in three) in the world have never had their births registered. Technology is already being used to help register and report on births. How can we give children an identity while avoiding the pitfalls of registration? How can we create solutions where identity can be verified and authenticated using a cell phone, smartphone, tablet, or any other device hooked to the Internet?
Transportation and delivery	Accessible and affordable public transport service and safe infrastructure for non-motorized transport such as cycling and walking are lacking in most developing countries in both urban and rural settings, especially for the critical "last mile." How can we improve informal transportation networks to make them safer and more efficient? How can we use big brands to help deliver essential services? How can we foster entrepreneurship so that it can leapfrog existing infrastructure barriers? What could these solutions look like if applied to a sharing economy model?
Wearable technologies	In simple terms, wearable electronics are used to make routine things easier to perform as well as to make life more sophisticated by offering several computing features in various day-to-day applications. These work mainly as a result of the integration of computing and communication devices. This is an industry ripe for disruption. Can we create wearable technology that addresses true social impact? Does wearable technology have the potential to save lives? Could we apply these technologies to real-time problems such as the 2014 Ebola outbreak?
Learning	The worldwide market for e-learning may reach US$51.5 billion by 2016. How might we create a business model that is profitable and sustainable, and that brings quality learning content to learners globally? How do we create access to these tools and ensure retention in school, especially of girls?

market demand they had previously failed to perceive. The low-end netbook and tablet have proven successful with both developed and developing world consumers and were, for many technology companies, rare profitability bright spots during otherwise challenging economic times.[11]

Technology with the potential to promote inclusive growth is more likely to be developed when designing specifically to meet the developing world's constraints. It is difficult to do more than "tinker at the edges" of innovation if the comfort of the advanced world is never left and technology is designed solely for developed world conditions.

Industry and private-sector technology companies thus have two distinct, important factors to consider. First, the creation of technology that meets the real

needs of the developing world represents opportunities both to expand potential markets and to increase the quality of life for a large number of people.[12] Second, a trickle-up, disruptive innovation effect can sometimes be seen whereby a focus on designing for the developing world leads to insights and ideas that change business in the developed world too (see Box 3). The impact of the OLPC on the wider tablet market (see above) is an example of this.

CONCLUSION

The field of ICT4D is evolving and expanding rapidly, and ICT4D projects are taking on broader scopes and scales, expanding into agriculture, governance, healthcare, and education. But we need at the same time to ensure that the critical analysis of best practices and lessons learned continues. The quality of people's lives and their ability to move out of poverty and live lives with increased levels of freedom and opportunity are at stake. It is a complex issue, and no aspect of it—hardware, software, or operational conditions—can be ignored.

Innovations in ICT4D not only become more widely adopted across the developing world, but may even become "disruptive" technologies for all markets. It is worth noting that the explosive uptake rates of mobile phones and mobile money services in sub-Saharan Africa were unanticipated in either scope or scale.[13] The commercial underestimation of these markets was astonishing. Only a few hundred thousand African mobile network subscribers were expected, and M-PESA began as a corporate responsibility experiment.

Matt Dalio, CEO of Endless, sees the commercial opportunity very clearly:

> Billions of people are about to have smartphones. But the people who build the apps that power those smartphones in Silicon Valley, in Venture firms and in engineering communities think of the next tier down and think "poverty." People still think of the world as an "economic pyramid." This is a tragic misconception. The world isn't a pyramid, it's a bell curve. One where "poor" and "poverty" are two very different things and lives at the middle of the pyramid look nothing like lives at the bottom of the pyramid. So who is focused on this (very large) middle of the pyramid? The answer is: almost nobody. We need to design the hardware and services needed by this market. It is the business opportunity of our era.[14]

Are we at risk of grossly underestimating these markets again and, of even greater concern, even completely missing opportunities altogether? Imagine the inclusive growth and development that could be achieved if more commercial ICTs were designed specifically for the needs and constraints found in the developing world, rather than discovered by luck or by accident.

NOTES

1 Harris et al. 2011.

2 Waugamon, 2014.

3 ITU 2009, p. 1.

4 Deloitte et al. 2012, p. 4.

5 For details about the M-PESA program, see Safaricom's website at http://www.safaricom.co.ke/personal/m-pesa/nchi-na-safaricom-m-pesa.

6 DOT Force 2001, Foreword.

7 Gerster and Zimmerman 2005.

8 United Nations System Task Team on the Post-2015 UN Development 2014; OECD 2014.

9 Schmidt 2014.

10 Kraemer et al. 2009.

11 Hosman and Baikie 2013.

12 London and Hart 2004.

13 van Rensburg 2012.

14 Dalio 2014.

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