Research Article

Material Ecosystems: Theorizing (Digital) Technologies in Socioeconomic Development

Jenna Burrell

University of California, Berkeley, USA

Abstract

This article presents a material ecosystemic approach as a theoretical grounding for understanding digital technologies as potential catalysts of socioeconomic development. Through such an approach, talk of "technology" is replaced by talk of the "material." Material is understood as inclusive of the human-made as well as the natural, of human relationships, human bodies, and words spoken. And the social is always necessarily materialized. These elements provide some clues as to how to move toward an improved ethic of design. The case of mobile phone use for financial practices among low- and lower-middle-income urban Ugandans is offered as a substantive case. The particular assumptions of modernization underlying calls for "financial inclusion" and the distinction between informal and formal are reconsidered through the lens of material ecosystemic analysis.

Introduction

Development studies, as a commentary and critique of the aid sector and international governance, tends to focus on policy, institutions, and macroeconomic forces (Corbridge, 2007). What does it mean to act or to intervene in other ways, not through policy making, but through the material design of technological artifacts and systems? While technology has always been an integral part of visions of development, ideas about its particular material form have evolved and changed—from the massive industrialization projects of the post-World War II era, through the period of the appropriate technologies movement (with E. F. Schumacher's [1973] *Small Is Beautiful* as a watershed moment), to recent interest in digital technologies as potential salves for poverty. While the introduction of a novel "technology" has often been the centerpiece of development projects, efforts to develop a deeper theory of the role played by technology as material artifact, system, or technique in realizing the many and diverse goals of development have been limited.

A few scholars in the multidisciplinary field of information and communication technology and development (ICTD) have lamented the fact that ICT and D research has only lightly engaged with social theory despite its abiding concern with effecting positive social change (Duncombe & Boateng, 2009; Heeks, 2006; Walsham, 2013). Recent efforts in the space have begun to counter the absence of theory (see Kleine, 2013; Slater, 2013; Toyama, 2011). Without theory, these scholars note, ICTD efforts often fall into repetitive tracks, offer insights with only short-term applicability, and suffer from a general narrowness of approach. Without considering more deeply the scope of socioeconomic development (and technology's role in it), such work tends to be confined within a space of ideas defined and measured by domain-based interests, or "sectoral silos,"[1] such as health, agriculture, or education. Theory could be put to use as a way to guide thinking into more expansive possibilities for technology and system design.

In the absence of a well-developed theory, a number of assumptions about the relationship between technology and social progress have prevailed in ICTD research and practice. One notable tendency is the treatment of ICT as a homogeneous category. This category, containing unspecified devices, is credited with certain

general, beneficial effects. For example, the outcome documents of the UN/ITU World Summit on the Information Society were rife with references to ICTs, although with infrequent mention of any particular devices or platforms. A 2012 review of the ICTD literature found "ICT in General" to be the object of study in 49% of research publications (Gomez, Barton, & Fiore-Silfvast, 2012). A related tendency is the treatment of technology not as a *means* to particular development goals, but as an *end* in and of itself. An example of this is found in a recent report of UNESCO's statistical commission on ways to measure ICT for development (United Nations, Economic and Social Council, 2014). The contribution of the report was a set of proposed metrics on the price, availability, and adoption of ICTs. The report argues that ICT diffusion and adoption, in general, can be treated as evidence of development. Approaches imbued with the above assumptions often problematically exclude the possibility that any sort of *harm* might follow from the dissemination of ICTs.

Design efforts in the ICTD space must contend materially with technology and its properties and, consequently, are less prone to homogenizing ICTs and overgeneralizing their effects. However, such work exhibits its own distinctive and problematic habits of thought. One tendency is to draw an absolute distinction between designers and users, such that the former is implicitly attributed with an exaggerated agency. The result is often overreaching expectations of control and stability in the outcomes of design practice, a notion that designed objects or systems should be used only or principally in predicted and intended ways.[2] This leaves only a weak role for populations targeted to benefit from ICTs. Such "beneficiaries" are expected to make a decision to adopt these offerings, but are granted little agency beyond this.[3] Agency expressed by users that diverges from these intended uses may be invisible, or worse, it may be delegitimized and cast as misuse.

Similar points have been raised in existing critiques and in efforts to develop a theory for ICTD. Kleine (2013) pursues a rich, multidimensional definition of development, drawing from Amartya Sen's capabilities approach. She proposes a framework that examines ICTs' relationship to development goals, effectively recentering tech in the role it plays as a means to other development outcomes. Kleine does not, however, specifically tackle or problematize the role of the designer in contrast to that of the user. Toyama (2011) tackles assumptions about technology as an inherently progressive force, arguing instead that technologies merely amplify human intent. However, Toyama's argument doesn't firmly break with the tradition of treating ICT as a homogenous category and does not present a way to disaggregate the distinct materialities of devices and systems within that category. What I propose is a unifying effort to develop theory in order to guide ways of thinking about the pursuit of design as "aid." A properly examined ethic of design that is aligned with evidence and experience and that is given structure in theory could serve as a guide for researchers and practitioners pursuing ICTD interventions.

I propose a material ecosystemic approach informed by work in the field of science and technology studies (STS). In STS scholarship the relationship between technology and society is a central concern. What I propose derives from certain premises of actor-network theory, particularly the principle of "*relational materiality*" which posits that the effects of a device, technology, or system are non-inevitable, flexible, and emergent (Akrich, 1992; Latour, 1991; Law, 1992, 1994, 2010). These effects unfold in an object's use out in the world. This reincorporates the significance of the varying *context* of use[4] into the discussion in a more grounded way. It challenges the naturalization of role hierarchies, particularly of designer and user by setting the expectation

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2. *Pressure in the aid sector to measure the impact of interventions through randomized controlled trials in the name of accountability and, more specifically, the recent efforts toward instituting "pre-analysis plans" in aid assessment (Casey, Glennerster, & Miguel, 2011) fuel this tendency by forcing project outcomes to be defined precisely in advance. This precludes consideration of the adaptations and unanticipated uses of technology that emerge in use. Adaptation in use has long been noted by historians of technology and others. See Fischer (1992) on the telephone in America and for an ICTD example, see this longitudinal study of CGNet Swara, a citizen participation system by Marathe, O'Neill, Pain, & Thies (2015).*
3. *Rogers text* Diffusion of Innovations *(1995) is a case in point. His focus is on drivers of technology adoption in "developing" regions but he considers almost nothing of the subsequent use of those technologies.*
4. *For further thoughts on recovering context through theory, see Diniz, Bailey, and Sholler (2014).*

that all human actors express agency in relation to one another and to and through material forms (and also that those material forms push back).

Vignette #1

In this article I consider an area of current and active interest in ICTD: mobile phones as a tool of personal finance and mobile money services. This article develops a theoretical orientation, using an empirical case to illustrate aspects of theory. The case draws from fieldwork on mobile phone use and financial practices carried out by the author and her research collaborators in urban Kampala, Uganda as well as in several rural areas of Uganda over the years 2007–2013 (see Appendix I for details on methods). Fieldwork in the summer of 2013 specifically examined the incorporation of mobile phones into the financial practices of low- and lower-middle-income Ugandans. I use these insights to address and critique the opposition set up between formal vs. informal financial instruments by researchers and practitioners when framing the topic of mobile money and m-banking. The formal is typically treated as preferable to the informal, and *financial inclusion* is understood as the process of extending the boundary[5] of the formal so that it encompasses more of the population. The goal, therefore, is to bank the unbanked (Batchelor, 2008; Morawczynski, Hutchful, Rangaswamy, & Cutrell, 2010). In the broadest version of this thinking, inclusion of the poor in formal financial practices is considered a complement to their informal practices (Collins, Morduch, Rutherford, & Ruthven, 2009). More narrowly, formal financial practices are occasionally endorsed to entirely supplant preexisting informal practices that are cast as irresolvably inadequate (de Soto, 2000; Prahalad, 2004).

The formal/informal distinction predates the ubiquity of mobile phone use among unbanked populations in Uganda and elsewhere. It inherits largely from prior development-sector interest in microfinance (Ruthven, 2002). The arrival of the mobile phone as a tool of financial inclusion has thus been absorbed into this preexisting framing as a new way to make financial practices more formal. The overarching theory of change accords with the modernization paradigm (with formalization as one of its key tenets), but is, at the same time, abstracted from the material particularities of the mobile phone. I suggest that this is a lost opportunity for seeing how the mobile phone as a system of value storage and transfer might in other ways (and perhaps according to an altogether different paradigm) yield development outcomes. As a way to introduce a material ecosystemic approach, I start with an example that shows what such an analysis would look like in making sense of the observable world. To demonstrate this, I explore liquidity as a descriptor for emergent material practices of managing value among Ugandan users of mobile phones and mobile money services. This grounding highlights an inventiveness with the mobile phone driven by mobile phone users themselves.

Mobile Phones and Financial Liquidity

Financial liquidity generally refers to the ease of convertibility of financial stores (assets and accounts) into spendable cash. It is not inherently a good or bad thing, but can be allied to a particular need or issue. Liquidity (or illiquidity) is effected through different forms of constraint, which often take on unambiguously *material* characteristics. The classic piggy bank, for example, is meant to create light resistance to spending, enacting a certain illiquidity. To access the piggy bank's funds means destroying the storage container (which can only be restored through an additional expenditure). Likewise, withdrawal fees (for early withdrawal from a retirement savings account, for example) are intended to increase the likelihood that funds remain untouched (to maximize the total sum). The constraint operates on the sum of the fund itself, reducing its amount as a tradeoff for liquidity.

In the Ugandan context, the keeping of livestock is a useful example for thinking outside archetypal financial instruments by taking into account preexisting material assemblages or ecosystems that support stored value and processes of saving and spending. The example of savings-in-livestock also helps expand the notion of a material ecosystem as cutting across the human-made, the natural, and (as in this instance) the nonhuman living. In rural Ugandan villages, livestock such as chickens, goats, and cows were often

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5. As an example of framing by using the metaphor of a boundary, or frontier, see Porteous' (2005) The Access Frontier as an Approach and Tool in Making Markets Work for the Poor. *For a critique of such a metaphor, see Mitchell (2007).*

described explicitly as a kind of financial strategy relevant to the question of liquidity. In particular, the future potential for livestock to multiply and, in this way, to gain in value tempered a short-term temptation to sell. As one rural farmer living in Kamuli district (interviewed on November 18, 2007) noted, "I have three female goats so when they give birth, then the number will automatically increase. . . . I sell them when they increase in number." Livestock has long been understood in this way as a store of value and even as "interest-bearing" in rural and remote regions where financial institutions such as bank branches do not exist.

Even among urban Ugandans interviewed during fieldwork in 2013, farming and livestock keeping were mentioned several times. Though remote from their home villages, Ugandans employed mobile phones to oversee farming activities from a distance. A mobile money agent (interviewed May 30, 2013), someone presumably well-versed in the newly available financial instruments, mentioned the eight goats she kept in her home village, which she monitored by phone. This highlights the complementary use of various money management techniques. New tools (such as the mobile phone) can, in fact, be put to use to better facilitate old and established practices (such as livestock keeping) rather than rendering them obsolete.

In Uganda, a type of wooden box, or *kaboxi* in the Luganda language, functions exactly like the classic piggy bank. This box was mentioned as a savings tool by several people in interviews. In an interview with Harriet (June 4, 2013), a fruit and vegetable vendor, she described such a box and how she would drive a nail into it to prise it open to withdraw its funds. In direct comparison to the illiquidity of the wooden savings box, she described her mobile money account, which she opened in 2010 as another place to store money. By comparison she noted that she doesn't have to "break it" to make a withdrawal. These examples describe an explicit material sensibility and comparison between what different tools afford and what they constrain.

In another kind of comparison Rita (interviewed June 4, 2013), the owner of a small provisions shop, described using her mobile money account as an intermediate step for savings that would eventually be deposited in the bank account she maintained with Bank of Africa. The mobile money account provided ease of deposit via the network of kiosks throughout the city that the bank (with its limited branches) did not. Rita describes creating an assemblage bringing together various "instruments" rather than choosing among them.

Several Ugandans noted the travel distance to bank branches, red tape, and long queues as hassles of using a bank account for savings, limiting their ability to make deposits, which is a necessary first step in accumulating savings. By the same token some of these same features of formal banking (not as abstractly envisioned, but as a lived reality) proved useful for limiting withdrawals and making savings more illiquid, that is, more resistant to spending. Rita noted that transferring money from her mobile money account to her bank account was a conscious attempt to make funds inaccessible. As she described in a later interview (June 17, 2013), the commute to the bank to make a withdrawal was an inconvenience that made it easier to refuse requests from friends for small loans. The convenience of her mobile money account, on the other hand, made it all too easy to accede to such requests. This has little to do with formality or even with the intentional design of financial services to protect savings; rather, illiquidity was a sometimes useful side effect of the poor service low-income urban populations experienced with banks.

A Materialist Approach

In this example of how Ugandans enhance their financial practices by using a repertoire of tools to make stored value more or less liquid, the mobile phone and mobile money services provided enhanced options for managing value. However, the newest technologies and services were not solely relied on for this; rather, they were incorporated into a range of existing tools. The practice of managing financial liquidity is linked to development in the most traditional economic sense: as boosting individuals' capacity to accumulate capital. Noting these practices of storing value do not prove any particular outcome (i.e., a measurable gain in accumulated capital or investment by individuals), but it does help illuminate the processes of technology use through which it could take place, grounded in practices that are *observed* to be taking place.

Moving to a higher level of abstraction toward theorization, I wish to extract the significant dimensions of a material ecosystemic approach that this description of liquidity has illustrated. To take a materialist stance to the question of social change is to consider how material things are critical and indispensable in constituting the social world. Actor-network theorists argue that the constitution of the social world is not only solidified

and secured by the materiality of human-made artifacts (such as mobile phones, computers, vehicles, etc.), but also through human bodies and bodily practices, and still further through nonhuman organisms (such as livestock) and nonliving entities (such as climate, topography, or geology). Going beyond actor-network theory, one may think of the social world as made through conceptualized entities, such as words, as they are materialized. Words are not in and of themselves material, but by necessity have material aspects (such as an instance when a word is bodily uttered by a person) and can yield material effects by provoking action in one who receives what is spoken. As the example of liquidity illustrates, a human-made object (a mobile phone, for example) enters into webs of mutual interaction with such diverse elements as farm animals, bank branches, and long queues.

To address the question of social change, we can start by acknowledging that if material forms and practices indispensably constitute the social world, then material changes, in turn, have the possibility of altering the social world. Importantly, this assertion about change should be understood as altogether separate from the question of the *valence* of this change, whether good or bad, and whether it is possible to count as development. This agnostic attitude toward change which is derived from a materialist stance interrupts the assumption that automatic positive benefit follows from the introduction of ICTs.

In this materialist framing, a way to effect some kind of change is through making objects, that is, by feats of human engineering that maintain an enduring form (such as a mobile phone). The invention of a material "thing" or system, however, is not the ultimate or even necessarily the most important element in effecting socioeconomic development. Once made it must then be enrolled into practices of use and also, as is so often overlooked, processes of distribution, maintenance, upkeep, and repair (see Jackson, Pompe, & Krieshok, 2010). The liquidity theme explored above managed to tackle only a narrow selection of practices, but it must be noted that such a variety of unglamorous practices, often excluded from the conventional notion of design, have been critical to the success of the mobile phone in the Global South.

While designing ICT devices or systems or software can be of social consequence, adopting the broadest possible notion of the material means that many other ways of consequential *doing* are also possible. The literature on social entrepreneurship, for example, highlights the broader work of assembling together people, policies, infrastructures, institutions, and funds in addition to what is conventionally identified as an engineered object or system (i.e., Martin & Osberg, 2007; Pitroda, 1993). Such material practices may not necessarily involve engineering *things* at all. Social movements and social activism must also be materialized in the sense that bodies come together to perform words, create texts (i.e., manifestos), etc. Human-made material designs in the form of objects or devices should not, I contend, be assumed a priori to have a special claim on effecting consequences of greater magnitude or positive impact. They should not be presumed to be inherently a force for socioeconomic advancement or for mitigating inequality. Therefore, while attempting to make a stronger (and yet nondeterministic) claim for digital technologies as potential agents of change, I do so with the conscious intent to flatten another implied hierarchy that places whatever is granted the label of technology at the apex of some notion of power and potency.

This reorientation in approach provides a more modest role for design work carried out with the conscious intent to effect positive social change. Design is a practice diffused throughout all human agents. *Design* is, as Herbert Simon (1969, p. 111) notes, "devising courses of action aimed at changing existing situations into preferred ones." Through this notion, one can begin to see how populations often characterized as beneficiaries of development interventions may be restored from *objects* in a system of instrumental logic to *subjects* in a process. By engaging with new devices, systems, or assemblages, they complete the material potential through practices of use. Where receiving populations make use of such interventions in ways that deviate from the imagined, intended, or planned, this is not misuse but must be examined for its own logic of change, specifically as an attempt to move from "existing situations into preferred ones."

A Material Ecosystem

While I have addressed the promise of thinking in terms of materiality, I have not yet defined what the notion of ecosystem brings to this theoretical framing. The notion of a material *ecology* or *ecosystem* brings attention

to this broader terrain and to the interactional effects among diverse materials. These interactions occur across species—human and nonhuman, natural and human-made, etc.

Consideration for the material forms and relational materialities that already exist in contexts where ICTD interventions will be introduced is a key method underlying a similar reorienting concept—that of *communicative ecologies,* devised by Tacchi, Slater and Hearn (2003)—to guide investigation of the realities and possibilities of new media in the Global South. In his 2013 book Slater clarifies and deepens the concept. He notes that the notion was intended to be "a tactical research manoeuvre," countering the formulation that presumes it is possible to isolate media impacts as context-free and monocausal in the Global South (Slater, 2013, p. 46). This was something Slater detected as the default assumption in his encounters with representatives of aid sector agencies as they began to direct attention to ICTs as a potential salve for poverty. In proposing that we think in terms of material ecosystems, I attempt something a bit broader, pertaining not only to the diversity of communication practices among people targeted for development, but also to the notion of social change.

In the all-togetherness of materials added to or rearranged, an effect emerges that is particular to that time and place because of the distinctive elements in place and the arrangement of relational forces (Law, 2010). This leads to a particular view of the possibility of scaling a development solution in the form of an object, such as a mosquito net or a laptop for children. For something such as mobile money services or microfinance, to succeed at scale ultimately means recognizing, addressing, and managing to adjust to the differing material baseline of any new site. Consequently, scaling a development intervention comes to be understood as an enormous and ongoing challenge of deployment and adaptation, not a matter of perfecting one universal design.

On a final note, to speak of ecology or ecosystem is also to address the dimension of time. Tim Ingold (2012) speaks in a similar way about an ecology of materials in which the material is animate, in a continual process of becoming. Ecosystems are living and evolving or devolving. Historical studies of technology have been notable for documenting one particular trajectory, that of a novel technology, at first highly visible and contested, eventually becoming invisible and mundane (Marvin, 1988). There is surely a lesson for ICTD work in these retrospective accounts of technology hype, which show that the valuable and enduring role technologies come to occupy in everyday use is often quite different from the one initially envisioned. Furthermore, to observe and account for this temporal dimension requires longitudinal studies that extend beyond a few years to a decade or more, something altogether rare in work on particular socioeconomic development interventions, and rarer still for studies of digital technologies as applied to socioeconomic development.

Vignette #2

I introduce a second emergent theme to complement the consideration of liquidity in the context of mobile phone use and financial practices. Like the liquidity theme, this represents practices of incorporating technology into an array of existing resources in the material environment, viewed from the user's perspective. This example adds to the discussion a focus on dangers and threats and the experience of mobile money users managing their own vulnerability. I end this interlude with an examination of possibilities for harm through new technologies and systems, something often problematically absent from ICTD work.

Mobile Phones and Security

Improvements in the security of funds transfer and storage were mentioned by urban Ugandans interviewed for this study as benefits of mobile money. But how precisely and *materially* were these benefits accomplished? One particular vulnerability of cash currency is the frictionless way it may be moved from the possession of one person to another without a trace or record of the transfer. And regardless of the transfer process (whether legitimate or not), it maintains the same value. This is a roundabout way of saying that cash currency has properties that make it appealing to thieves. There are ways to counter this that operate on the materiality of the currency itself such as ink packets set to explode in bags of cash stolen from a bank or unique serial numbers printed on bills. However, to implement such theft resistance requires particular circumstances or supporting infrastructures unavailable outside of banking institutions.

Mobile money accounts, as noted above, provide a degree of greater illiquidity compared to cash currency.

They make it somewhat easier to resist spending. Likewise, mobile money accounts are a step toward making accumulated value (that would otherwise be in the form of cash) more *inalienable*. They do this by disassociating value from physical form. Mobile phones are also highly vulnerable to theft. However, while a phone may be stolen, the value kept in a mobile money account associated with the phone is recoverable. The phone is a portal to a mobile money account, the state of which is registered, made redundant, and kept secure elsewhere through telecom networks and/or bank data storage systems. This disassociation of the value contained by the account with the apparent physical form creates a stickiness of money-value to the possessor registered in the system (albeit with a base assumption that the banking system is reliable and trustworthy).

The security advantage was clearly explained by Harriet (interviewed August 12, 2013), wherein she noted that if a thief steals your phone line, they do not have the PIN required to access your mobile money. The phone company can transfer and restore your account when you report the theft. Likewise, Lydia (interviewed August 16, 2013), by comparing mobile money directly to cash currency, noted that it is "much safer" to save with mobile money and that you can transfer the account if your phone line is taken, whereas when cash is stolen, "it's gone."

Theft was a real concern among study participants. In the midst of $2\frac{1}{2}$ months of research in Kampala, one of our research participants, Sammu, experienced an armed robbery in his home. Interviewed a day later (August 9, 2013) he noted that his new mobile phone, two pair of new trousers he had just purchased, and 170,000 Ush (US$66) in cash had been stolen. He described how two men in military uniforms armed with guns broke into his home and woke him. The cash they took he had intended to use to complete some transactions in his village, and the rest was to be given (as remittances) to his sister. Theft, he noted, was a widespread problem in his neighborhood.

Apart from theft there are the insecure practices of transferring money across distance through remittances and the broader issue of vulnerabilities when money (in the form of cash) travels by road. Carrying cash in large amounts while on the road is not unusual, particularly by Ugandans traveling from the city where they work to their rural home village where relatives expect support. Mobile money users discovered their mobile money account could be used as a way to stash money while traveling. Better yet, given the way the MTN mobile money service was designed, money deposited in an account and then withdrawn from that same account (even if at a new location) incurs no fees. This strategy of money transfer-to-self has become a way to minimize such a risk, as noted by Sammu (interviewed August 16, 2013).

Money transfer to others (usually to kin) over distance has generally been identified as the most significant emerging use of mobile money systems like Kenya's M-Pesa (Morawczynski, 2008). In Uganda, prior to the availability of mobile money services, this was accomplished through interpersonal networks. For example, many Ugandans hand over money to a relative who plans to visit the home village soon asking that they pass the money along to one's kin (typically to one's mother). Asking a taxi driver who is travelling to the area to carry money for you (and paying him a small fee for the service) was another practice. Whether the money would find its way to the intended recipient was far from certain. The overlap between people traveling to a destination and people you trust to handle a money transfer for you could be quite small. Henry, for example, used his brothers as intermediaries to send money to his mother, but eventually she reluctantly admitted that she hadn't always received the money he sent. To address the problem she obtained her own mobile phone and a mobile money account, though she still required someone to help her receive the funds at a mobile money kiosk. However, an improved degree of traceability was added to the process.

By overcoming security problems related to travelling with physical cash, mobile money serves to preserve and enhance what is generally categorized as an informal financial practice: remittances, motivated by obligation and need, that transfer money through social networks of kinship. While modern population movements from rural and outlying areas into African cities have, at times, been associated with a process of social distancing and the renunciation of kinship obligations, the immediate role of mobile money is that an informal practice (remittances) can be employed more reliably. Funds have an improved stickiness to their intended possessor and such transfers appear to gain in accuracy. The result is a hybrid materialization; users further invest in an informal practice rather than abandoning it once a technical and, in some sense, more formal infrastructure becomes available.

The theme of security raises the issue of risk mitigation and highlights practices of family support. In our findings such dependencies and vulnerabilities shape the material strategies of low-income Ugandans at least as much if not more than the desire to maximize financial accumulations. This account has gone as far as addressing observed practices and how they are changed by mobile phones to show expressed needs and priorities, but has refrained from assessing such change in normative terms. A material ecosystemic approach, in this way, leaves open the possibilities for finding *negative* change. In fair-minded and objective processes of knowledge building, this is necessary, yet ICTD contributions have often entailed research designs and frameworks for analysis that (perhaps following unwittingly from a Western equivalence between technology and progress) preclude the possibility of harm.[6]

In relation to the presumptions of positive change through formalization, several of the low-income Ugandans who participated in this study spoke of avoiding loans, particularly ones owed to an institution (such as a bank or microfinance organization) and noted the potentially dire consequences of defaulting. These concerns are not generally addressed in the push to financially "include." In particular, this so-called "inclusion" brings marginalized, presumably low-value customers into a relationship with a monolithic banking institution. As already noted, the lived realities of formal-sector banking services were of long queues and red tape. Citizens must cautiously negotiate their relationship with what may be an untrustworthy, partisan, or unstable government and with institutions like banks that offer few possibilities for recourse for ordinary customers if things go awry.[7] Normative assumptions about the financial inclusion for the poor lead to studies that measure, for example, formalization (i.e., numbers of new bank accounts opened by the unbanked, number of loans taken out by low-income customers) and declare success. They conceal failure outside the already-established terms of the debate. Thus, failure (if considered) is defined by the lack of formalization. Theoretical framings of value to ICTD must include possibilities to be disproven and for projects to fail, not only by not having the precise impact that was anticipated, but by yielding negative outcomes, including unanticipated outcomes.

Toward an Improved Ethic of Design

Critiques of development, particularly the body of work termed post-developmentalism, argue for a withdrawal from all efforts to "develop" another group or population as too tainted and irredeemable, as fundamentally neocolonialist (Corbridge, 2007). However, work singling out technology in such critiques has problematically treated technology as an overly fixed and homogenous class of material entities, saddling it with a specific and overgeneralized character (i.e., Ullrich, 2007). Technology, in post-developmentalist terms, is an expression of an inherent (and objectionable) ideology. It is often viewed as the handmaiden of development's "antipolitics" that obscures political problems by casting them as amenable to purely "technical" solutions (Ferguson, 1990).

In defending the possibilities of technology design and, more generally, of intentional material practice toward realizing social goals, we must address such arguments for blanket rejection as well as the promises of technology as a panacea. To recover the possibility of a form of ethical design practice, I have argued that we must start by thinking more systematically about technology (within the broader spectrum of the material) and its relationship to social change. Such thinking takes us beyond the conventional fallback position, the treatment of technology as a tool of optimization, formalization, and thereby, stealthily of some version of modernization premised on Western ideals.

In principle it is entirely possible for design to work in a positive direction toward dismantling structures

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6. *To give one example, a study by Perez and Ben-David (2012) undertook log data analysis of websites visited by users who had newly acquired Internet access in India. The research article posed the question, Does the Internet enhance the freedoms people enjoy? It then considered any information access as evidence of expanded freedom. Imagining the value of these sites to users, there was no consideration of the possibility that website visits might lead to negative freedoms. In particular, information sought could be part of efforts to carry out surveillance or control of others. Banking or e-commerce activities (or even email use) might put users in the way of scams. The information found might be propaganda or simply inaccurate. A challenge of log data analysis is that the intentions of users are unknown.*
7. *Note the subprime mortgage crisis in the U.S. as a case in point.*

of power and redressing inequalities. There are design movements already allied to and informed by critical theory (Sengers, Boehner, David, & Kaye, 2005) that consider (and alter) materially embedded values in computing as they relate to privacy, trust, and discrimination (Nissenbaum, 2001), practices of labor exploitation (Irani & Silberman, 2013), and practices invested in offering new platforms to support and amplify marginalized voices (Marathe, O'Neill, Pain, & Thies, 2015; Tacchi & Kiran, 2008). The potential comes from recognizing the material as consequential, but not as an automatic transfer of ideology in an unyielding and fixed form. A material ecosystemic analysis creates an awareness of this potential and a structured way to think about design practice.

Many past accounts of carefully observed technology-in-use throughout the Global South show how technology realizes its effects unpredictably. Such accounts, including some conducted by the author, are the foundation that this material ecosystemic approach is built upon. However, how might such insights lead to a more ethical design practice exactly? Such a practice could be implemented in the following ways: (a) require methods of design research or needs assessment and project evaluation that account for the agency of users (and other actors beyond the designer or design team) and that support and amplify that agency through further design iterations; (b) dispense with mere adoption or uptake of a technology as the primary marker and measure of project success; (c) deprivilege technology in design processes by considering whether low-tech or no-tech possibilities that address apparent needs would work better (see Densmore 2012); and (d) routinize the consideration of harm (not only non-impact) in project evaluations. This reorientation suggests compatible methods (ethnographic, participatory, action-oriented) and less compatible methods (controlled experiments, pre-analysis plans) on the grounds of what is the best way to intervene ethically.

It should also be noted that there are surely limits in the capacity of privileged designers or engineers to simply gift recognition and empower marginalized groups. Those in more privileged roles are not automatically able to understand the populations they wish to support and their needs and values simply by willing such insight, nor are they always able or willing to cede power or control over material resources and design processes. Particularly within any of the prevailing systems of institutional reward (whether aid agencies, industry, or academia), efforts that aim to enact a material ecosystemic approach (it should be fully acknowledged) may be penalized rather than supported. Perhaps what this suggests is that the design of new institutions (and not simply a better mindset or better methods for designers) is another critical part of the pursuit of an improved ethic of design.

Throughout this article I have studiously avoided the task of defining development. Robert Chambers uses a simple formulation, defining *development* as "good change" (Chambers, 1995, p. 174). What *good* is I leave as an open question. In addition to considering the perspectives of those meant to benefit from ICTD, one can turn for further insight to any number of sources of philosophical thought. In refiguring material practices (of design) and particularly in expanding thinking beyond fallback positions, there are well-reasoned frameworks specific to development such as Amartya Sen's argument in *Development as Freedom* (2000). There are also those unallied to development per se, but nonetheless concerned with the human condition such as Habermas' (1972) social theory of knowledge-constituting human interests. I select these two examples not at random, but to flesh out a particular ethic of development (and design) that resists the usual fallback to modernization.

In Sen, development is resolutely people-centric and remarkably expansive. It is the freedom of individuals to "lead the kind of lives they have reason to value" (Sen, 1999, p. 10). This work, which treats economic, political, and cultural freedoms in a nonhierarchical manner, is widely recognized as an advancement on earlier definitions of development from economics that used economic growth as a proxy for all other gains. In Habermas (1972) there is additional recognition of the workings of power and of the nature of (and need for) human emancipation, something present but highly circumscribed in Sen's approach. Habermas in his theory of knowledge (1972) shows a way to get beyond the orthodoxy of *science-minded development,* defined as extending control over the natural world in securing human health and well-being (i.e., through modern agricultural techniques, vaccination programs, etc.). This approach, he notes, is a human interest in *technical control.* In both Sen's capabilities approach and in Habermas' critical theory of human interests, technical control

alone does not encompass nearly enough of what human liberation could or should be (nor, presumably, does it encompass the full scope of possibilities for material intervention). Notably, where poverty and the routes to beneficial change are considered a matter of control over nature, this omits dynamics within society and matters of wealth distribution, inequality, power, and oppression. When technology is only wedded to one type of human interest, development-as-antipolitics is the unsurprising result.

Richer philosophical thinking has the potential to inspire ways to pursue design that move toward empowering or emancipating the marginalized. To act through technological designs, to lend one's expertise toward needed social change when in partnership with and with respect for the agency of populations who may benefit from these designs, can be soundly ethical and powerfully impactful. Reframing design through the material ecosystemic approach is an effort to open up many new possibilities for such work.

Conclusion

In a demonstration of material ecosystemic analysis, I considered the material practices of low-income, urban Ugandans, specifically, their use of mobile phones and mobile money. This case focused on personal finance and day-to-day money management, a concern close to the heart of development as a matter of economic growth. In development discourses the conversation about money management has previously been framed around financial inclusion, a notion which inherits largely from prior development-sector interest in microfinance. The mobile phone (and mobile money or m-banking) is incorporated into a preexisting normative goal, financial inclusion, without close consideration of its particular materiality in context.

I have argued for the need to more thoroughly and systematically theorize technology and its relationship to social change and to notions of socioeconomic development in particular. To do so I proposed that as a first move, we replace talk of *technology* with talk of the *material* to disrupt developmentalist thinking that is stuck in default ideologies. These default ideologies cloud both a clear view of the actual practices unfolding on the ground and of the broader spectrum of possibilities. The second move is to expand consideration of the material from the human-made to include the *natural,* human relationships (and human bodies), as well as groups gathered and words spoken, acknowledging the wide range of ways that human actors bring together diverse materialities to realize particular aims. The third move, then, is to understand that the *social* is always necessarily materialized. I say it is necessarily materialized because to be social is to be shared in some way, and to be shared requires some kind of externalization. An *aim* must be enacted materially to be of consequence. From this perspective, the material has a key role in social change. Change can and must be brought about through new material realities and reconfigurations.

While I have offered a theory of social change through the material, I have not offered an accompanying theory asserting how exactly to assess the valence of change as good or bad. This was intentional. Drawing from Herbert Simon's definition of *design* as "devising courses of action aimed at changing existing situations into preferred ones" (1969, p. 111), I offered instances of design by mobile phone users in Uganda who attempt to bring about their own preferred situations through the resources they now have at hand. Systematic philosophical thinking about benefits, value, and, ultimately, "development" can and should be brought to bear on design efforts. By drawing from scholarship of and about the Global South, such as that of Amartya Sen, or scholars of general human emancipation, such as critical theorist and philosopher Jurgen Habermas, ICTD scholars and practitioners can chart a new course, one that does not assume technological designs will, by default, embody modernization myths or limit effects to the domain of "technical control" alone. This theoretical approach is meant as encouragement to designers and engineers who wish to direct their skills toward ends other than boosting corporate profits, shareholder value, efficiency, or the domination of nature. To do so, a realigned ethic of design, one that accords with this idea of material ecosystem, means treating one's own aims and possessed knowledge with modesty, cooperating with stakeholders throughout the design and use processes, paying attention to the existing material practices, and acknowledging the necessary and productive (if unpredictable) material practices that emerge after an invention/intervention is released into the wider world. ∎

Acknowledgments

Jenna Burrell, Associate Professor, School of Information, University of California, Berkeley, USA. jburrell@berkeley.edu

References

Akrich, M. (1992). The de-scription of technical objects. In W. Bijker & J. Law (Eds.), *Shaping technology/building society: Studies in sociotechnical change* (pp. 205–224). Cambridge, MA: MIT Press.

Batchelor, S. (2008). Mobile phone-enabled payment systems: Transformation 2008. *Enterprise Development and Microfinance, 19*(1), 13–30.

Casey, K., Glennerster, R., & Miguel, T. (2011). *Reshaping institutions: Evidence on aid impacts using a pre-analysis plan* (Working paper 17012). Cambridge, MA: National Bureau of Economic Research. Retrieved from http://www.nber.org/papers/w17012

Chambers, R. (1995). Poverty and livelihoods: Whose reality counts? *Environment and Urbanization, 7*(1), 173–204.

Collins, D., Morduch, J., Rutherford, S., & Ruthven, O. (2009). *Portfolios of the poor: How the world's poor live on $2 a day.* Princeton, NJ: Princeton University Press.

Corbridge, S. (2007). The (im)possibility of development studies. *Economy and Society, 36*(2), 179–211. doi:10.1080/03085140701264869

Densmore, M. (2012). Claim mobile: When to fail a technology. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 1833–1842).

de Soto, H. (2000). *The mystery of capital: Why capitalism triumphs in the West and fails everywhere else.* New York, NY: Basic Books.

Diniz, E., Bailey, D., & Sholler, D. (2014). Achieving ICT4D project success by altering context, not technology. *Information Technologies & International Development, 10*(4), 15–29.

Duncombe, R., & Boateng, R. (2009). Mobile phones and financial services in developing countries: A review of concepts, methods, issues, evidence and future research directions. *Third World Quarterly, 30*(7), 1237–1258. doi:10.1080/01436590903134882

Ferguson, J. (1990). *The anti-politics machine: "Development," depoliticization and bureaucratic power in Lesotho.* Cambridge, UK: Cambridge University Press.

Fischer, C. (1992). *America calling: A social history of the telephone to 1940.* Berkeley, CA: University of California Press.

Gomez, R., Barton, L. F., & Fiore-Silfvast, B. (2012). The changing field of ICTD: Content analysis of research published in selected journals and conferences 2000–2010. *Proceedings of the Fifth International Conference on Information and Communication Technologies and Development*—ICTD '12 (pp. 65–74).

Habermas, J. (1972). *Knowledge and human interests.* Boston, MA: Beacon Press.

Heeks, R. (2006). Theorizing ICT4D research. *Information and Communication Technologies and Development, 3*(3), 1–4.

Ingold, T. (2012). Toward an ecology of materials. *Annual Review of Anthropology, 41*(1), 427–442.

Irani, L., & Silberman, M. (2013). Turkopticon: Interrupting worker invisibility in Amazon Mechanical Turk. *Proceedings of the SIGCHI.* doi:10.1145/2470654.2470742

Jackson, S. J., Pompe, A., & Krieshok, G. (2012). Repair worlds: Maintenance, repair, and ICT for development in rural Namibia. In *Proceedings of CSCW '12* (pp. 107–116).

Kleine, D. (2013). *Technologies of choice? ICTs, development and the capabilities approach.* Cambridge, MA: MIT Press.

Latour, B. (1991). Technology is society made durable. In J. Law (Ed.), *A sociology of monsters: Essays on power, technology and domination* (pp. 103–132). London, UK: Routledge.

Law, J. (1992). Notes on the theory of the actor-network: Ordering, strategy, and heterogeneity. *Systems Practice, 5*(4), 379–393.

Law, J. (1994). *Organizing modernity.* Oxford, UK: Blackwell.

Law, J. (2010). The materials of STS. In M. Beaudry & D. Hicks (Eds.), *The Oxford handbook of material culture studies* (pp. 173–188). Oxford, UK: Oxford University Press.

Marathe, M., O'Neill, J., Pain, P., & Thies, W. (2015). Revisiting CGNet Swara and its impact in rural India. In *Proceedings of the Seventh International Conference on Information and Communication Technologies and Development—ICTD '15* (pp. 1–10).

Martin, R., & Osberg, S. (2007, Spring). Social entrepreneurship: The case for definition. *Stanford Social Innovation Review,* 28–39.

Marvin, C. (1988). *When old technologies were new: Thinking about electric communication in the late 19th century.* New York, UK: Oxford University Press.

Mitchell, T. (2007). The properties of markets. In D. MacKenzie, F. Muniesa, & L. Siu (Eds.), *Do economists make markets? On the performativity of economics* (pp. 244–275). Princeton, NJ: Princeton University Press.

Morawczynski, O. (2008). Surviving in the "dual system": How M-PESA is fostering urban-to-rural remittances in a Kenyan slum. In *Proceedings of the IFIP WG* (Vol. 9, pp. 110–127).

Morawczynski, O., Hutchful, D., Rangaswamy, N., & Cutrell, E. (2010). The bank account is not enough: Examining strategies for financial inclusion in India. *Proceedings of the Fourth International Conference on Information and Communication Technologies and Development.* doi:10.1145/2369220.2369242

Nissenbaum, H. (2001). How computer systems embody values. *Computer,* March, 117–120.

Perez, Y. V., & Ben-David, Y. (2012). Internet as freedom—Does the Internet enhance the freedoms people enjoy? *Information Technology for Development, 18*(4), 293–310.

Pitroda, S. (1993). Development, democracy and the village telephone. *Harvard Business Review, 71*(6), 66–79.

Porteous, D. (2005). *The access frontier as an approach and tool in making markets work for the poor.* Somerville, MA: Bankable Frontier Associates.

Prahalad, C. K. (2004). *The fortune at the bottom of the pyramid.* Philadelphia, PA: Wharton School Publishing.

Rogers, E. (1995). *Diffusion of innovations.* New York, NY: Free Press.

Ruthven, O. (2002). Money mosaics: Financial choice and strategy in a West Delhi squatter settlement. *Journal of International Development, 14*(2), 249–271.

Schumacher, E. F. (1973). *Small is beautiful: A study of economics as if people mattered.* London, UK: Blond and Briggs.

Sen, A. (2000). *Development as freedom.* New York, NY: Anchor Books.

Sengers, P., Boehner, K., David, S., & Kaye, J. J. (2005). Reflective design. In *Proceedings of the 4th Decennial Conference on Critical Computing: Between Sense and Sensibility* (pp. 49–58).

Simon, H. A. (1969). *The sciences of the artificial.* Cambridge, MA: MIT Press.

Slater, D. (2013). *New media, development and globalization: Making connections in the Global South.* Oxford, UK: Polity Press.

Tacchi, J. A., & Kiran, M. S. (2008). *Finding a voice: Themes and discussions.* New Delhi, India: UNESCO.

Tacchi, J. A., Slater, D., & Hearn, G. N. (2003). Ethnographic action research: A user's handbook. New Delhi, India: UNESCO.

Toyama, K. (2011). Technology as amplifier in international development. In *Proceedings of iConference '11* (pp. 75–82).

Ullrich, O. (2007). Technology. In W. Sachs (Ed.), *The development dictionary* (12th ed., pp. 275–287). London, UK: Zed Books.

United Nations Economic and Social Council. (2014). Statistical commission report of the partnership on measuring information and communication technology for development: Information and communication technology statistics, E/CN.3/2014/8 (March 4–7, 2014).

Walsham, G. (2013). Development informatics in a changing world: Reflections from ICTD2010/2012. *Information and Communication Technologies and Development, 9*(1), 49–54.

Appendix I: Description of Methods

This article draws on the author's own fieldwork stints in rural Uganda in 2007 and 2008, but primarily focuses on a 2½-month period from late May to mid-August 2013, when the author's research team conducted fieldwork in Kampala. The author remotely directed a pair of student collaborators, who carried out this phase of the investigation.

Fieldwork was carried out in three stages. First, an initial unstructured interview with diverse Kampalans (30 in total) on the general topic of mobile phone use and its role in the financial lives of the interviewees and his or her family. Second, a selection of 11 interviewees were invited to participate in short weekly interviews where the course of conversation was lightly structured by the task of working through the interviewees' phone call log. Third, at the final stage of the fieldwork an "exit interview" was conducted where interviewees were asked directly to offer their thoughts at a higher level of analysis.

One major challenge of this work had to do with gaining fine-grained reports on a topic (daily practices of mobile phone use and money management) that was possibly sensitive but also mundane and, thus, often unmemorable. This difficulty was what justified the weekly interviews and the use of phone call logs as a way to focus on the interviewees' most recent activities. Given the time commitment involved, participants who consented to the weekly interviews were financially compensated at the end of the research period. In general, descriptions of process, practice, and strategy were of central interest, while quantifications (of money borrowed, lent, saved, or earned) were treated only as rough approximations.