It's not *just* illiteracy

Indrani Medhi
Microsoft Research India
196/36, 2nd Main Sadashivnagar
Bangalore, India
indranim@microsoft.com

Ed Cutrell
Microsoft Research India
196/36, 2nd Main Sadashivnagar
Bangalore, India
cutrell@microsoft.com

Kentaro Toyama
School of Information
University of California
Berkeley, USA
kentaro_toyama@hotmail.com

There is increasing interest in using computing applications towards the socio-economic development of the poor. However, because poverty commonly correlates with illiteracy, researchers have identified various usability challenges that low-literate users may encounter in interacting with traditional text-based UIs. To counter such problems, researchers have proposed non-textual UIs for these users. However, most current work focuses exclusively on illiteracy (the inability to read) *per se*, with little recognition to other problems or the overall context in which a user is situated.

In this paper we suggest that the inability to read is only one of several possible concerns that prevent useful interaction of existing computing (PC and mobile phone) UIs by low-literate users. Through our ethnographic and usability studies with 400 low-literate, low-income subjects across India, the Philippines and South Africa, we find a host of nuanced issues which mediate how a user interacts with computing technologies. Such issues include: cognitive difficulties, collaboration, cultural etiquette, experience and exposure, intimidation, mediation, motivation, pricing, power relations, social standing, and others. We observe that these factors can have far-reaching influence on the design of UIs as well as services for low-literate populations.

User Interfaces, Low-Literate Users, Illiteracy

1. INTRODUCTION

There is increasing interest in applications of computers and mobile phones for serving economically poor populations in the field of Information Communication Technology for Development (often abbreviated ICT4D), the goal being to find ways for technology to alleviate poverty and boost socio-economic development (Brewer et. al., 2005; Toyama & Dias, 2008). One of the greatest challenges faced in developing such applications is that potential users may lack significant formal education. In fact, 41% of the population in the least developed countries is non-literate (UNESCO, 2007), and even the literate among the poor are typically novice users of computer technologies.

A recent body of work aims at designing user interfaces (UIs) on PCs, PDAs and mobile phones for low-literate adult users (Chipchase, 2005; Griesdale et. al., 1997; Huenerfauth, 2002; Medhi et. al., 2006; Parikh et. al., 2003; Sherwani et. al., 2007). Researchers have identified various usability challenges that low-literate users may encounter in interacting with traditional text-based UIs. To counter such problems, non-textual UIs that use voice, graphics and video have been proposed. However, most current work focuses exclusively on illiteracy (the inability to read) *per se*, with little recognition to other problems or the overall context in which a user is situated.

In this paper we suggest that the inability to read is only one of several possible concerns that prevent useful interaction of existing computing (PC and mobile phone) UIs by low-literate users. Through our ethnographic and usability studies with 400 low-literate, low-income subjects across India, the Philippines and South Africa, we find a host of nuanced issues which mediate how a user interacts with computing technologies. Such issues include: cognitive difficulties, collaboration, cultural etiquette, experience and exposure, intimidation, mediation, motivation, pricing, power relations, social standing, and others. We observe that these factors can have far-reaching influence on the design of UIs as well as services for low-literate populations.

Proceedings of Name of conference

2. RELATED WORK

Most previous work in UIs for non-literate users has focused exclusively on illiteracy (the inability to read) *per se*, by mainly examining the mechanics of interfaces on PCs, PDAs and mobile phones. Researchers have recognized the value of imagery, and have advocated extensive use of graphics (Grisedale et. al., 1997; Huenerfauth, 2002; Medhi et. al., 2006; Parikh et. al., 2003a; Parikh et. al., 2003b). More specifically, it appears that static hand-drawn representations are better understood than photographs or icons (Medhi et. al., 2007). Some authors note that the use of numbers is acceptable, as many non-literate people can read numerical digits (Parikh et. al., 2003a; Parikh et. al., 2003b). Other work has focused on ultra-simple navigation as a design goal (Griesdale et. al., 1997), or on removing anxieties about technology use. For example, looping video clips which include dramatizations of the overall usage scenario have been found to be effective in reducing barriers to usage by first-time users (Medhi and Toyama, 2007).

Apart from work that focuses on PCs and PDAs, there is some research that looks at mobile phone UIs for low-literacy users. Researchers have recognized the value of voice feedback (Medhi et. al., 2006; Parikh et. al., 2006, Plauche and Prabaker, 2006) and speech interfaces (Boyera, 2007; Plauche and Prabaker, 2006; Sherwani et. al., 2007). Others have questioned suitability of menu-based navigation for novice users (Jones et. al., 2007) and have discussed designs that advocate fewer menus and dedicated buttons for this target group (Lehrman, 2007).

However, there is very limited amount of work that looks beyond the mechanics of the UI, at broader issues which can influence the use of technology artifacts among populations with limited exposure to technology. One study examines coping mechanisms of low-literate users when confronted with traditional mobile interfaces (Chipchase, 2006; Chipchase, 2005). Another paper discusses issues such as pricing, peer learning and social dynamics that can affect the use of technologies among developing world populations with low exposure to technology. (Ramachandran, et. al., 2007). But this particular work targets a broader population and does not focus exclusively on low-literate users, like we do. Moreover, in our study of low-literate users, we discover many more nuanced qualitative issues beyond pricing, peer learning and social standing which mediate how a user interacts with computing technologies in general. We suggest that apart from illiteracy per se, there exist other possible concerns that prevent useful interaction of existing computing (PC and mobile phone) UIs. In addition to studying the human-device interaction issues, we examine the overall context in which the user is situated.

3. PREVIOUS RESEARCH

The issues discussed in this paper, emerge from our previous work in designing UIs for first-time, low-literate users for a range of applications on PCs and mobile phones around job information, health information and mobile money-transfer. Through this research, we arrived at several UI design principles that we believe could apply to many non-literate groups new to computer use. However, there remain other factors beyond strict usability not covered by our previous work, which we discuss here, that could potentially enhance design of interfaces as well as services for these user groups. The findings summarized here come from a variety of separate research projects of ours. These ideas have never been synthesized in the way they are being done in this paper, although hints of the ideas have appeared in previous publications.

In the following section we describe the target community and the methodologies employed for our previous research:

3.1 Target community

In the course of our work we have studied more than 400 subjects from communities across India, the Philippines and South Africa. Our subjects were usually functionally illiterate or semi-literate (able to read only with difficulty and effort) but numerate (could read Indo-Arabic numerals 0,1,2,3...); had low levels of formal education (highest education attained being schooling up to the eighth grade of the K-12 education system or its equivalent across the three countries); and had zero experience with personal computers. Apart from these traits, we looked for varying degrees of experience with using mobile phones—there were both users and non-users of mobile phones in our subject base.

Subjects were typically domestic workers and daily wage labourers like plumbers, carpenters, construction workers, mechanics, vegetable vendors, weavers, farm hands, fishermen, drivers, etc. Household income ranged from USD 20 – USD 200 per month. Some of our subjects had television sets, music players and gas burners, but these were not owned by all households. A few had seen computers in person (but again, none had ever used them). The subjects' primary languages were Kannada, Hindi and Tamil in India; Tagalog in the Philippines; Afrikaans, Xhosa and Zulu in South Africa. Our subjects did not speak English for the most part, but strongly associated it with wealth and prestige.

3.3 Methodology

Across the separate projects in our previous research, we drew from guidelines of *contextual design* and *goal-driven design,* in which techniques of ethnography were used to gain a deep understanding of the subjects, within the context of their specific goals (Cooper and Reimann, 2003). We observed users in specific contexts, analyzing and synthesizing

information gathered, and incorporating these insights into a design. We held open-ended interviews, both one-on-one and in groups, on different information domains we were designing for. We visited individual households to talk to people about their daily activities and to observe their living environments. The interviews and participant observation techniques gave us a broader understanding of the local context and user needs. The ethnographic study involved over 450 hours in the field across India, the Philippines and South Africa.

Subsequently, we used an iterative design process to develop the UIs, where we elicited constant feedback from the subjects for each iteration. We used this information to evaluate our designs and incorporated the necessary changes into each following prototype.

We tested our final prototypes through formal usability tests with our subjects. We defined a task for each of the users and embedded tasks into a story like in the "Bollywood method" (Shaffer, 2004). In this method, tasks are embedded in dramatized stories involving the subject, which has been found to be better at motivating subjects toward the desired tasks, even for computer novices. Particularly in a context with asymmetric power relations with the experimenter, and where subjects tend to be reserved about giving feedback to people they perceive to be in authority (as experimenters were perceived to be), this became an invaluable tool for encouraging honest feedback. We also made a number of modifications to ensure that subjects were as comfortable in the testing environment, as possible. In all cases, we performed the testing in a physical setting which was routine for the participants—their own homes and work places, non-profit organization offices which were known to them, etc.

4. ISSUES BEYOND ILLITERACY

Overall, we found that there were a number of usability challenges which people experienced while interacting with traditional text-based UIs, on both mobile phones and PCs. In addition to the general inability to read text, one of the other major challenges was the difficulty in navigating hierarchical menus in current information architectures. Particularly for mobile phones, we also saw that people experienced a host of barriers in current input mechanisms.

We designed non-textual UIs based on the design principles we had established, using combinations of voice, graphics and video, to help overcome usability barriers. Rigorous user evaluations showed that our designs were strongly preferred over standard text-based interfaces and that first-time, non-literate users were, in fact, able to navigate through our UIs meaningfully. However, there still remains a lot more to be accomplished in order to make computing technology interfaces truly usable for our target audiences. Through our ethnographic and usability studies conducted during this UI design research, we discovered a host of nuanced issues, beyond strict usability, which in our opinion could further inform the design of UIs for these populations. These are informal qualitative observations, which we have so far not followed up with quantitative tests. We offer these here as possible hypotheses for future verification.

4.1 Ability to navigate text-based UIs through rote learning exists

As has been mentioned earlier, to help non-literate users overcome usability barriers on traditional text-based UIs, researchers have proposed non-textual UIs that use graphics, voice and video (Griesdale et. al., 1997; Huenerfauth, 2002; Medhi and Toyama, 2007; Medhi et. al., 2006; Parikh et. al., 2003; Sherwani et. al., 2007). Typically, one would expect that a non-literate person has absolutely no ability to make sense of a traditional text-based UI because of his/her inability to read. And as the level of literacy increases, the ability to navigate UIs also increases in a somewhat linear fashion. This relationship could be imagined like shown (by the dashed red line) in the schematic graph, in Figure 1. However, based on our research, we suspect that even non-literate users have some capacity for basic navigation of current text-based interfaces, which happens through rote learning.

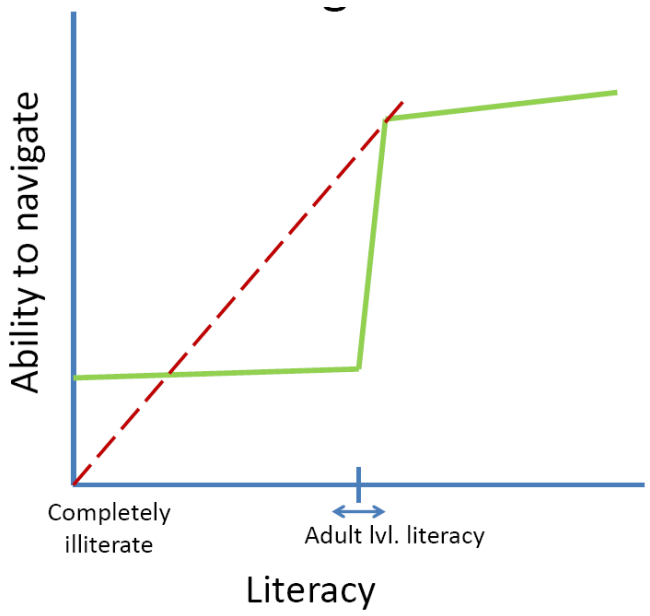


***Figure 1**: Schematic graph showing relation between literacy and ability to navigate; graph not to scale*

In our work designing money transfer UIs on mobile phones, we had asked our subjects to perform a set of tasks (dialling a phone number to call a friend, writing a short SMS text message to a friend), both on their own

handsets and on mobile phones provided by us (in order to determine how much of their usage was by rote memorization). Diagrams of the perceived menu structures are shown in Figure 2. In many cases, the diagrams had mention of text labels of physical buttons (e.g. button "ABC"), instead of the actual function accomplished by the button. Secondly, there were many subjects who were able to perform the tasks on their own handsets but could not accomplish them on other handsets. In another instance, a subject narrated an ATM transaction she had once carried out. To explain the interaction, she first drew the physical keypad of the ATM as she remembered it (numbers within square boxes as seen in Figure 2). She did not know any of the functions on the screen, but remembered the exact order in which she had pressed various physical buttons to carry out the transaction.

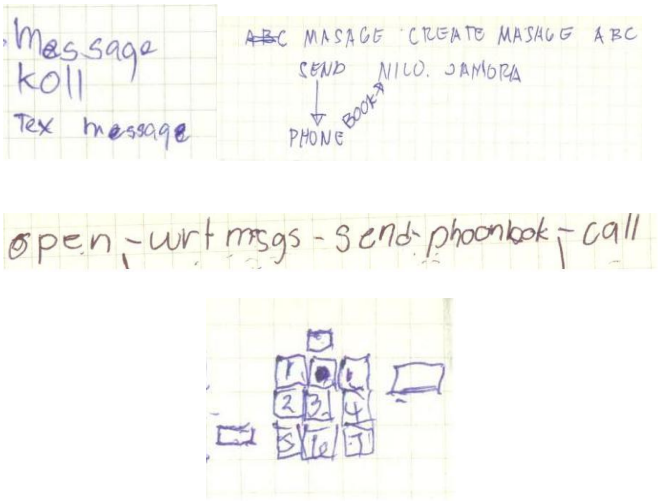


Figure 2: *Diagrams produced by semi-literate subjects to represent menu structures for user tasks*

All of these observations suggest that even the completely illiterate have some ability to navigate, even if it is by rote memorization of UI steps. So the (literacy-ability to navigate UIs) schematic graph may in fact look like the solid line in green, in Figure 2. After some degree of literacy and education, people have enhanced ability for navigation– at least, with some training. In between, there appears to be an "S" curve with a steep slope that sharply divides those who can learn moderate UIs and those who cannot. It is not yet clear where the point of inflection occurs, but it does seem to cleanly divide the literate from the non-literate. In terms of formal education, our conjecture is this point of inflection occurs around Grade 6 of the K-12 education system ("adult level literacy"), when the ability to read simple sentences with fair amount of fluency is attained. But this needs to be established through rigorous evaluation. It seems as though once this level is attained, some fundamental change in cognitive capacity occurs from a UI perspective.

These observations may suggest that if the menus of existing text-based UIs are kept relatively short, there might be ways to leverage the abovementioned ability of non-literate users, for them to be able to navigate these UIs.

4.2 It's not just illiteracy

Through previous research, we find the inability to read, is only one of several possible concerns that prevent useful interaction of existing computing UIs. Among other issues, first there is intimidation of technology caused by one's social standing, which seems to influence a user's comfort level with technology. During qualitative user studies and usability tests, on PCs for example, in spite of ensuring that subjects feel comfortable, we have seen that because of the implicit class hierarchy between our subjects and the experimenter, our older participants usually fear that they would "break the device" if not used "correctly" and would be taken to task for it. This is especially true of older subjects in India, who appear to have low confidence on a technology that is new to them. We suspect this may be related in some way to our older participants growing up in caste-entrenched times, in India.

Figure 3: *Low-technology living environments of our subject communities*

Our subjects mostly live in low-technology contexts without much exposure to computing technology in

their living environments, and sometimes the physical appearance of the device used in usability studies also can be intimidating to our users. From what we have seen, the more expensive the device appears; higher is the level of discomfort in using that technology.

Another issue mediating the use of computing technologies is the inability of our subjects, in many cases, to apply instructions provided not just through the UI but also by the human experimenter in a usability test setting. Our subjects have not been exposed to institutionalized education contexts. And the associated culture of following detailed procedural instructions, we suspect, is therefore unfamiliar to our subjects. This unfamiliarity could be the reason why our subjects were unable to apply instructions from what they hear to actual practice on the UI.

Finally, the lack of knowledge of application context also seems to influence how subjects interact with various technologies. To register for an existing mobile money-transfer service, our subjects were required to fill up details such as their mother's maiden names. Most of our subjects did not understand what the term meant. Information such as mother's maiden name is usually required for banking protocols and most of our subjects being unbanked had no previous context for this information field.

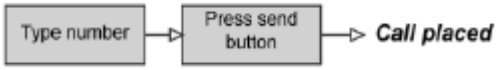
4.2 Even light exposure to non-ICT technology facilitates overcoming usage barrier

Given that our target audiences live in low-technology environments, we find that even light exposure to technology facilitates overcoming usage barriers. In this context, "technology" is not necessarily ICT technology, and broadly means any complex mechanical tool used to interface between two or more domains that facilitate more effective action of one domain upon the other.

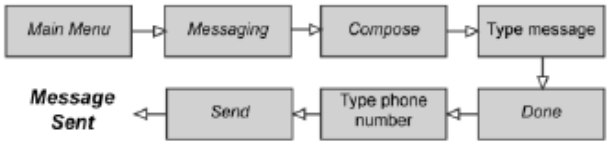
We observed in some cases that subjects whose professions required them to interact with any complex mechanical tool on a daily basis (public two-wheeler drivers in Philippines with their vehicles, machine garment makers in South Africa with their sewing machines) were more comfortable interacting with PCs and mobile phones as compared to subjects who had negligible active interaction with technology in their professional work (vegetable vendors, domestic workers). Our conjecture is that familiarity with and understanding of the mechanics of a complex tool results in greater comfort with technology devices in general.

4.3 Motivation trumps usability challenges

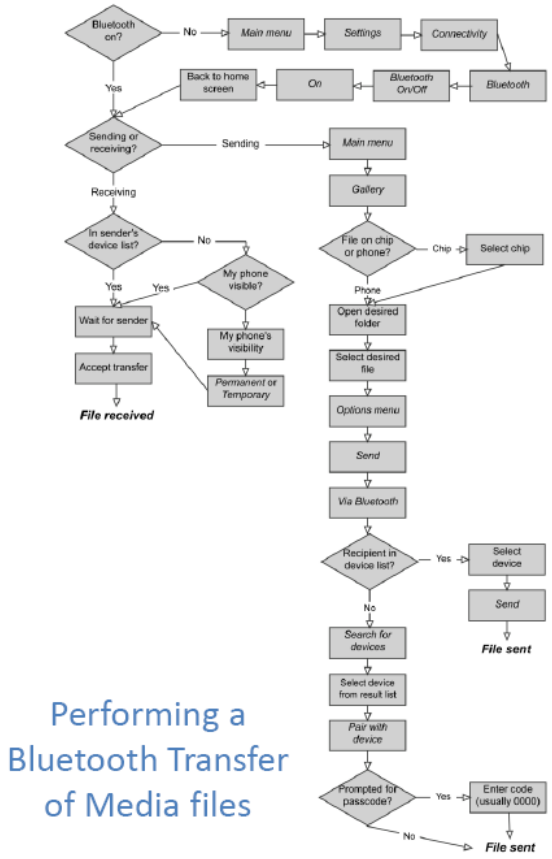
In UI design work for low-literate users, usability challenges are usually attributed to educational deficiencies of potential users. Most current research work in this area ignores the centrality of user motivation in determining adoption of services. Through our work, we find that motivation indeed is a powerful force, and influences how a user interacts with technology in general.



(a)



(b)



(c)

Figure 3: *Steps involved in (a) making a call, (b) sending a text message, (c) performing a Bluetooth transfer of media files*

Motivation, though, is often contingent on what the technology application has to offer. We further observe that what we as researchers might perceive as needs

for poor communities, need not necessarily be what they desire for themselves. The level of motivation may therefore vary between perceived needs and desires. A research study shows that often expectations of intended beneficiaries and interventionists of ICTD projects are not aligned (Ratan and Bailur, 2007). Another study shows that recipients of such development projects often will work a lot harder to meet their desires (Diga, 2007). In our case, we find that the motivation to adopt, if powerful enough, trumps the obstacles in the path of adoption of a new technology.

In previous work around mobile UIs, researchers have found that low-literate users mostly use phones only for voice calls but rarely for asynchronous communication such as texting (Chipchase, 2005; Medhi et. al., 2009). This is because of the relative complexity, in terms of number of steps, involved in the task of texting. However, through our ethnographic study on sharing and consumption of entertainment media on low-cost mobile phones in urban India, we find that novice technology users will traverse multiple levels of complex UI navigation, if the motivation exists (Smyth, et. al., 2010). In this particular case, the motivation is for the desire to be entertained. We observed that users traversed as many as 19 steps (Figure 3) to do Bluetooth transfer of entertaining content consisting of music, music videos, film dialogs, and comedy clips. This was despite minimum technical knowledge.

This observation suggests that while designing services for low-income, low-literate populations, in addition to focusing on users' inability to read, it is important to pay attention to the level of user motivation for the concerned application.

4.4 Collaborative usage enhances user experience

Information technologies have been traditionally designed for individual usage scenarios. However in the case of our low-income, low-literate populations, we have observed that during single-subject tests, subjects usually appear nervous and uncomfortable when asked to perform a task. A group, on the other hand, seems more comfortable, while interacting with a computer.

We had installed a computer "kiosk" with a health information dissemination application, as part of our health UI research, at the lobby of a hospital for low-income, low-literate communities. When we had instructed people to use the system, one by one, we saw that they were really anxious and hesitant to even come near the kiosk. However, at one point when we were conducting subject studies, a group of patients at the hospital began playing with the application between our formal tests. It was surprising to see that they seemed more confident, suggesting ideas to one another, discussing the purpose of the application, watching over each other's shoulders, advising each other, learning from each other, and interacting more boldly with the computer.

Figure 4: *Collaborative usage of health kiosk at a hospital*

Collaborative usage scenarios have been studied in the context of education amongst children in resource constrained environments (Pawar et. al., 2006). However, in our knowledge, in the context of adult users with low-literacy levels, group usage scenarios have not been examined so far. We feel there is the potential for future UI design research taking into account a collaborative user model for low-income, low-literate adult users, which could be particularly beneficial.

4.5 Presence of proximate deters learning motivation for individual usage

Our subjects usually reside in communities with high population density and variation in literacy and digital literacy levels. One research work discusses how very often non-literate members of slum communities seek proximate replacements, to interact with a technology owned personally or by the household. A proximate could be termed a technology aide for semi- or non-digitally literate members. They help realize a technological interaction, by aiding to overcome its navigational, functional, or user interface complexity (Sambasivan et. al., 2010).

Through previous research, we have observed that the presence of a proximate could deter learning motivation for individual usage among semi- or non-digitally literate members. Consider a 58-year old fisherman Edulan in Philippines. He is non-literate and owns a mobile phone. He can dial calls from scratch (without using the phonebook) himself, by dialling a phone number every time he needs to make a call. But when he receives a text message on his phone, does not know how to open and read it. However, he has his

proximate nephew Cirilo, who checks his text message and reads it out to him. Sometimes, Cirilo even sends a reply to the sender on Edulan's behalf. In most such cases, in our research, we observe that as long as someone like Edulan has his resource Cirilo, the motivation to learn to use more sophisticated functions on the mobile phone by self, is usually low.

We find that the proximate could also be someone outside of one's immediate family or household. Let us take the example of existing mobile money-transfer services where cash transaction locations could be retail outlets (neighborhood grocery store, chemist shop, etc.) which intermediate between the customer and the bank/telecom company linked to the service. In a number of cases, we observed that processes such as registration and troubleshooting were often done by a proximate (e.g. service agent + shopkeeper of the grocery store). It was observed that users would often hand over their phones and even secret passcodes to the proximate (Ratan and Medhi, 2009; Ratan 2008). Qualitative interviews revealed that the motivation to learn sophisticated functions on the mobile money-transfer interaction by oneself was low, given the proximity, approachability and trusted relationship with the agent.

Figure 5: *Mobile Money transaction at a retail agent location*

This observation about use of proximates for carrying out technology interactions was consistent even in the case of PCs. In one of our research projects, we had installed a PC in the house of a low-literate, low-income family in a slum community in India. Relevant to this paper, the goal was to understand what applications the family would want and what usability issues they might encounter while using the PC. We observed that not even once during the one year long longitudinal study, did the 35-year old mother in the household ever touch the PC. She would wait for either her 6-year old daughter to come back from school or her 27-year old digitally literate brother-in-law to get back from work. Upon return, the daughter or the brother-in-law would play the movie requested by her on the PC, which she would then sit back and watch.

Most current information systems are designed and tested for individual usage scenarios. The above observation suggests that designing of applications for low-income, low-literate communities, may require designing with respect to the collective literacy and digital-literacy capabilities of the social unit.

4.6 Cultural etiquette, pricing of service, power relations shape social norms of technology usage

There are a number of other issues which shape the social norms of how a technology is used in a specific context. We observed that social etiquette within a cultural context was important in determining the extent to which mobile phones were used. In the Philippines, we noted that when in a co-located group setting (e.g. while dining with family or friends) individual members within the group would be busy fiddling with their mobile phones, texting or playing games, instead of interacting with one another. This behaviour seemed to be socially accepted in the case of Philippines, but may not be acceptable in another cultural context. We caution our readers against generalizing this observation to every group setting in the Philippines, but there are grounds to suspect that our observations will transfer to other social interaction settings, at least within the Philippines, if not to other countries with a similar cultural ethos.

The social approval for such behaviour may be one of the reasons why usage of texting in the Philippines is much higher than, specific to our case, India or South Africa. Even among low-income, novice technology users in the Philippines, we find that there is a fair amount of usage of texting which is done in transliterated Tagalog (in the English script).

We also find that the pricing of a service influences how and to what extent a technology is used. Revisiting the example of usage of texting in the Philippines, we find that the cost of making a phone call is often five to six times the cost of sending a text message. In some cases, within a given network, texting between two phone numbers is free of cost. Given this enormous price difference, texting was the preferred mode of communication for many low-income individuals and usually the volume of usage was very high. Among our subjects, we found people who had up to 50 "text-friends". These were people whom our subjects had never met, but had "found" through forums on media such as broadcast radio. Some of the low-income, novice technology subjects we spoke with sent up to 100 text messages per day.

Power relations and hierarchies within a given social context also seem to shape how mobile phones are used. Consider the case of Dingane in South Africa, the 50-year old father of Dikeledi, a 16-year old girl. Dingane told us about how he was increasingly concerned about his teen-aged daughter staying out till late almost every night. He complained about how she would not take or return his panic calls to find her whereabouts. In such a situation, Dingane would assume his daughter does not have enough mobile phone balance (mobile minutes) to receive or return a call. He would then go ahead and "transfer mobile currency" to her phone, hoping she would call back. Dingane had started suspecting that Dikeledi had started using this as a "strategy to make a quick (mobile) buck" from her father even while she had enough mobile currency to make or receive calls.

However, in the case of 28-year old Thandiwe, giving even a "missed call" to his employer was considered inappropriate. Missed call is defined as calling a number and hanging up before the mobile's owner can pick up the call. Most of such calls are requests to call back immediately (Donner, 2007). Thandiwe said that he did give missed calls to the "wealthier" friends in his social circle, who he thought would have money to call him back. However, because of the power relation, Thandiwe was not comfortable exercising the missed call rule with his employer.

These issues of cultural etiquette, pricing of service and power relations seem to be important in shaping how a technology is used in specific social and cultural contexts and should therefore be taken into account while designing applications and services for low-income, low-literate and novice technology user populations.

5. CONCLUSIONS AND FUTURE WORK

In this paper, we discuss a host of issues which suggest that apart from the inability to read, there exist a number of other possible concerns that prevent useful interaction of existing PC and mobile phone UIs by low-income, low-literate users. Most previous work focuses exclusively on the mechanics of the UI, and proposes non-textual interfaces to help low-literate users overcome barriers of usage on existing text-based UIs. However, in our work, in addition to studying the human-device interaction, we examine the overall context in which the user is situated. Through our previous research with over 400 low-literate, low-income subjects across India, the Philippines and South Africa and 450 hours spent in the field, we find that there are a lot of nuanced qualitative issues beyond strict usability, which mediate how a low-literate user interacts with computing technologies in general. These issues include: cognitive difficulties associated with UI interaction; availability of collaborative user experiences; social etiquette acceptable in a specific cultural context; experience and exposure to technology in general; intimidation caused by technology; mediation available through proximates; motivation to use a given application; pricing of a service; power relations within a social group; one's social standing; and others. We present these as informal qualitative observations, which have so far not been followed up with quantitative tests. These are offered here as possible hypotheses for future verification. We observe that these factors can have far-reaching influence on the design of UIs as well as services for low-literate populations.

For future work there could be multiple areas of investigation, one of which could be the systematic empirical investigation for each of the issues discussed here. This could be done by following up the qualitative observations in this paper with quantitative studies. There could also be more in depth qualitative studies of the overall context in which a user is situated, to possibly discover more of such nuanced issues important for the design of UIs and services for low-income, low-literate populations.

6. ACKNOWLEDGEMENTS

Toyama's contributions have been enabled by the generous sponsorship of Nokia Research Center.

7. REFERENCES

Boyera, S. (2007). The Mobile Web to Bridge the Digital Divide? In *IST-Africa Conference*. Maputo, Mozambique.

Brewer, E., M. Demmer, B. Du, M. Ho, M. Kam, S. Nedecschi, J. Pal, R. Patra, S. Surana, and K. Fall (2005). The Case for Technology in Developing Regions. *IEEE*.

Chavan, A. (2004). The Bollywood Method. Presented in Schaffer, E. *Institutionalization of Usability; a Step-by-Step Guide*. New York:Adisson Wesley. 129-130.

Chipchase, J. (2005). Understanding Non-Literacy as a Barrier to Mobile Phone Communication. Retrieved September 15, 2008, from http://research.nokia.com/bluesky/non-literacy-001-2005/index.html.

Chipchase, J. (2006). Literacy, Communication, and Design. In *UIAH*.

Cooper, A., & Reimann, R. (2003). *About Face 2.0, The Essentials of Interaction Design*. Wiley Publishing Inc.

Diga, K. (2007) Mobile Cell Phones and Poverty Reduction: Technology Spending Patterns and Poverty-level Change Among Households in Uganda, Master's Dissertation, University of KwaZulu-Natal, Durban.

http://www.w3.org/2008/02/MS4D_WS/papers/position_paper-diga-2008pdf.pdf Retrieved on 12/12/2009

Donner, J. (2008). Research Approaches to Mobile Use in the Developing World: A Review of the Literature. *The Information Society* , *24*(3).

Donner, J. (2007). The Rules of Beeping: Exchanging Messages Via Intentional "Missed Calls" on Mobile Phones, in *Journal of Computer-Mediated Communication*, vol. 13, no. 1, 2007

Grisedale, S., Graves, M., & Grünsteidl, A. (1997). Designing a graphical user interface for healthcare workers in rural India. In *ACM Conference on Human Factors in Computing Systems (CHI)*. ACM. Retrieved September 18, 2008, from http://portal.acm.org/citation.cfm?id=258869.

Huenerfauth, M. Developing design recommendations for computer interfaces accessible to illiterate users. Master's thesis, University College Dublin, (2002).

Jones, M., Buchanan, G., Thimbleby, H., & Marsden, G. (2000). User interfaces for mobile web devices: WWW9 mobile workshop position paper. In *International World Wide Web Conference*.

Lehrman, S. (2007). Dialing in. Mobile phones target the world's nonreading poor. *Scientific American*, *296*(5), 30-31.

Medhi, I., Gautama, S. N. N., & Toyama, K. (2009). A Comparison of Mobile Money-Transfer UIs for Non-Literate and Semi-Literate Users. In *ACM Conference on Human Factors in Computing Systems (CHI)*.

Medhi, I., Prasad, A., & Toyama, K. (2007). Optimal audio-visual representations for illiterate users. In *International World Wide Web Conference*.

Medhi, I., Sagar, A., & Toyama, K. (2007). Text-free user interfaces for illiterate and semiliterate users. *Information Technologies and International Development*, *4*(1), 37-50.

Medhi, I., & Toyama, K. (2007). Full-Context Videos for First-Time, Non-Literate PC Users. In *International Conference on Information and Communication Technologies and Development*.

Parikh, T. S., Javid, P., Sasikumar, K., Ghosh, K., & Toyama, K. (2006). Mobile phones and paper documents: Evaluating a new approach for capturing microfinance data in rural India. In *ACM Conference on Human Factors in Computing Systems (CHI)*.

Parikh, T., Ghosh, K., & Chavan, A. (2003a). Design Considerations for a Financial Management System for Rural, Semi-literate Users. In *ACM Conference on Human Factors in Computing Systems (CHI)*.

Parikh, T., Ghosh, K., & Chavan, A. (2003b). Design Studies for a Financial Management System for Micro-credit Groups in Rural India. In *ACM Conference on Universal Usability*.

Pawar, U. S., Pal, J., and Toyama, K. (2006) *Multiple mice for computers in education in developing countries*, IEEE/ACM Int'l Conf. on Information & Communication Technologies for Development

Plauché, M., & Prabaker, M. (2006). Tamil Market: A Spoken Dialog System for Rural India. In *ACM Conference on Human Factors in Computing Systems (CHI)*.

Ramachandran, D., Kam, M., Chiu, J., Canny, J., and Frankel, J. (2007). Social Dynamics of Early Stage Co-Design in Developing Regions. In *ACM Conference on Human Factors in Computing Systems (CHI)*.

Ratan, A. L., and Medhi, I. Using technology to deliver financial services to low-income households: a preliminary study of Eko customers in India, Microsoft Research Technical Report, November 2009.

Ratan, A. L. Using technology to deliver financial services to low-income households: a preliminary study of Equity Bank and M-PESA customers in Kenya", Microsoft Research Technical Report, June 2008.

Ratan, A. L. & Bailur, S. (2007). Welfare, Agency, and "ICT for Development". In *International Conference on Information and Communication Technologies and Development*.

Sambasivan, N., Toyama, K., Cutrell, E., & Nardi, B. (2010). Intermediated Technology Use in Developing Communities. In Proc. *ACM Conference on Human Factors in Computing Systems (CHI)*.

Sherwani, J., Ali, N., Mirza, S., Fatma, A., Memon, Y., Karim, M., et al. (2007). HealthLine: Speech-based Access to Health Information by Low-literacy Users. In *International Conference on Information and Communication Technologies and Development*.

Smyth, T., Kumar, S., Medhi, I., and Toyama, K. (2010). Where There's a Will There's a Way: Mobile Media Sharing in Urban India. In *ACM Conference on Human Factors in Computing Systems (CHI)*.

Toyama, K., and Dias, M.B. (2008). Information and Communication Technologies for Development. *IEEE Computer*, 41(6), 22-25.

UNESCO. (2007). UNESCO Institute of Statistics Data Centre, Regional literacy rates. Retrieved June 7, 2009, from http://stats.uis.unesco.org/unesco/TableViewer/tableView.aspx?ReportId=201.