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ORIGINAL ARTICLE

Beyond "yesterday's tomorrow": future-focused mobile interaction design by and for emergent users

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Abstract Mobile and ubiquitous computing researchers have long envisioned future worlds for users in *developed* regions. Steered by such visions, they have innovated devices and services exploring the value of alternative propositions with and for individuals, groups and communities. Meanwhile, such radical and long-term explorations are uncommon for what have been termed emergent users; users, that is, for whom advanced technologies are just within grasp. Rather, a driving assumption is that today's high-end mobile technologies will "trickle down" to these user groups in due course. In this paper, we open the debate about what mobile technologies might be like if emergent users were directly involved in creating their visions for the future 5–10 years from now. To do this, we report on a set of envisioning workshops in India, South Africa and Kenya that provide a roadmap for valued, effective devices and services for these regions in the next decade.

Keywords Emergent users · Innovation · Mobiles · Wearables

1 Introduction

For many people in the *developed* world, ownership of a sophisticated smartphone is a given and has been for some years. That is, they have relatively easy access to general-purpose programmable phones based on common platforms (Android, iOS, etc.), in which much of the utility depends on data connectivity, and where there are advanced sensors and actuators available to support interaction. Increasingly, these users are also creating, accessing, sharing and transacting large amounts of content over very high-speed data connections via a range of web services. Hundreds of millions of people in *developing* regions, though, cannot access these devices and services

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due to a range of constraints including economic, geographic and educational issues. A smaller but growing group is just beginning to get access to advanced mobile devices and services, these being their first exposure to sophisticated computing technologies. There is, then, a growing constituency of "emergent" users—people for whom such services are just within reach [9]. Our work is focused on serving this constituency, ensuring their voices are included in the design conversation.

In the developed world, mobile and ubiquitous computing researchers commonly envisage potential long-term futures. In contrast, for developing regions there has been a focus on more immediate concerns, with a wide range of studies considering how to apply low-end or limited features of more advanced devices and services to support user groups. While this work is incredibly important (and impactful), we argue that without a complementary longer-term perspective, emergent user groups will be destined to always having to adapt to technologies designed from a "first world" perspective. That is, technology will "trickle down" so that as these devices become the developed world's "yesterday", emergent users inherit them as their "tomorrow".

In this paper, we take envisioning approaches common in developed region contexts and apply them in developing regions to help move the research and development agenda in different directions. The work surfaces novel forms, materials and frameworks for interaction in these contexts. It should not be assumed that emergent users will simply follow the path of developed world users. They may shape these technologies in different ways, and these technologies may themselves need to be developed to allow this shaping to be more profound and effective.

In the work reported here, participative design techniques and research findings surface features of devices and interface styles on the basis of emergent user encounters and dialogue that we feel do point towards a different future. These directions hint at a path that is not simply a "second-hand" version of what is predicted in the developed world (of hand-me-down form factors, interfaces and interaction styles); it is, rather, a future that builds on the visions from the bottom—from the emergent users themselves.

Even as recently as 5 years ago, this future-focused work might have been characterised as "blue sky" (or, more cynically, "pipe-dream"). Now, however, technological and economic trends make such thinking credible, and indeed necessary. A better digital infrastructure for these users is just within grasp. For instance, in India there are already low-end smartphones available for around ₹1500 ($20). This paper's contribution is to help reorientate researchers, designers and developers to ensure that when the successors of such technologies are in their hands, emergent user communities will not be under- or poorly served.

As part of a 3-year extended engagement with communities in India, South Africa and Kenya, we carried out five co-ordinated participatory design workshops over a 14-day period with emergent users in Bangalore, Cape Town and Nairobi. The workshops were developed in conjunction with our local researchers, partners and contacts in each of the regions, and the results have been used to guide prototyping work subsequently with follow-up fieldwork in each of the areas. These places were chosen to provide input from a spectrum of emergent user communities in terms of socio-economic characteristics and concerns.

In the remainder of this paper, we present and reflect upon the findings of these workshops. This work contributes by being a first example of longer-term future envisioning undertaken directly with emergent user groups. As well as providing a palette of design ideas for future products and services created and influenced by emergent user insights, we hope this work will encourage others to work with long-term design goals in these contexts and to develop some of the ideas we describe.

2 Background

A substantial body of work by both the ICTD (ICT for Development) and HCI4D (HCI for Development) communities has explored how low-end mobile devices and simple network services can be appropriated without the resources and in contexts "alien" to the technologists who initially created the infrastructure. In an early example of this work, Donner [10] provides a report on the practice of missed calls, where one user calls another and deliberately terminates before it is answered, to communicate intentions ranging from "call me back" to "I am thinking about you" without incurring cost. Meanwhile, the Spoken Web, developed by IBM Research India, was an ambitious infrastructure providing information services from any handset over a standard, analogue telephone network and supporting, for instance, interactive forums [1]. Further examples of services that have been explored with or are popular as deployed systems in developing regions include Awaaz.De [30] and CGNet Swara [27].

Some researchers argue that there needs to be a continued focus on these basic, low-end phones and infrastructures due to their likely sustained use in rural regions in the medium term (e.g. [43]). While it is possible to add some sophisticated features to these devices (e.g. providing back-of-device gestures over DTMF [36]), our work is motivated by a desire to equip developers over the longer term with a set of techniques that utilise the sensor

and actuator rich platforms that users in these regions will be able to access in the further-out future.

While many emergent users still use very low-end devices, increasingly there are affordable "feature-phones"—precursors to smartphones that typically have better memory, low-end data network capabilities, cameras and simple web browsers. Prior research on these feature-phones has considered a range of techniques to provide information services in developing regions. For instance, the CAM system showed how a basic cameraphone could facilitate data entry by rural users, with paper forms linking to digital interaction via visual codes [29]. Snap and Grab extended the use of image processing, enabling content selection and transfer between public displays and mobile phones via Bluetooth and photo-based media filtering [24]. StoryBank provided access to media in rural India, exploring search and browsing to combine mobiles and community displays [13]. If these papers and technologies point towards a different way of leveraging the functions of featurephones, then it is likely that the powers encapsulated in smartphones could evolve in even more distinct ways.

Moving to smartphones, we see that in the developed world, innovative mobile techniques that have been proposed over the past 20 years (e.g. [17]) are now found in commercial products. The challenge is to see emerging interaction technologies envisaged from a "first world" perspective as building blocks and departure points for the radically alternative interfaces and interaction styles that will be needed to address emergent user constraints and contexts [40]. While there are several examples of using basic features of smartphones in emergent contexts (e.g. video and audio for storytelling [14]), there are only a very limited number of studies reporting on how advanced features of such devices could be deployed (e.g. one example uses mobile inertial sensing and pico projection to provide a content creation infrastructure for rural users [37]).

We believe that there are huge opportunities to provide effective information and service interaction by repurposing and disruptively innovating the expected mobile infrastructure in these regions. For example, in developed world contexts there has been much interest in natural user interfaces, embraced because they provide ways to use purportedly more human styles of communication (gestures, movement, eye-gaze, audio, speech). Given the barriers that computer-centric interactions can present to some emergent users [25], "natural" approaches appear to hold a great deal of potential. Recently, then, the potential of such an approach for content sharing over basic phones was demonstrated: by holding their mobiles together, rural farmers were able to share voice forum contents instantly, removing the need for complex interactions with the device or remote voice service [31]. The range of effective interaction styles possible on low-end devices illustrates the potential in this area, but the future devices such users will own, with their step-change in processing, sensors and possible interaction with other easily deployable devices, will allow for huge leaps in the sorts of services that can be provided.

While current and future smartphone technologies offer exciting possibilities, simply taking innovations widely seen in developed contexts and expecting them to be effective out-of-the-box and in the hands of emergent users is nave. These technologies have been forged with a first world perspective, and their value (and limitations) for emergent users needs to be understood and appropriated carefully [2]. For example, early work with users in South Africa showed that hierarchical menus—widely used in developed regions—may cause problems in cultures where relationships are understood in a non-hierarchical, "grandmother-mother-daughter," sense [41]. Turning to more sophisticated interactions, where the device learns about the user over time and adjusts the interface or optimises performance: these strategies are challenged in emergent user contexts where sharing of devices is far more common, and the phone is less of a personal technology and more of a communal one [39]. Cultural etiquette and other factors may also impact on the forms of gesture or other visible interactions that can be deployed [35]. Further, in regions where material resources are limited, the notion of using special physical objects to afford tangible interaction appears unsustainable. Finally, existing multimodal techniques are often underpinned by or complement textual and visual literacy-based screen interactions (e.g. consider navigation applications that combine text, touch, location and inertial sensing as inputs with graphical, textual and audible output). In emergent user contexts, we cannot just simply deploy approaches that require these forms of western-centric information interaction skills.

While developed world users can choose which device to use depending on its suitability for a task, emergent users may not have this luxury. Increasingly, developed world users have access to a mobile, tablet, fixed home or work computer, smart TV and wearables. If such an ecosystem of devices is useful and desired in one world, what will be the equivalent in more resource-constrained contexts [11]? In working with emergent users in the workshops reported here, we go beyond simple mobile solutions and innovate coherent, flexible infrastructures.

Previous studies have stressed the importance and effectiveness of co-developing and evaluating prototypes for these groups in a highly participative way. Emphasis is placed on sustained and sustainable engagements with communities as current real needs and values are surfaced and addressed [5]. Such grass-roots situated research and

development has become increasingly popular more widely, with many studies making reference to "in the wild" approaches that go beyond simple out of the lab deployments [8].

In contrast, future-focused ideation workshops typically involve a series of design probes and activities over several hours, with the aim of provoking and inspiring imaginative longer-term possibilities for digital devices and services (e.g. [38]). Recently, Mankoff et al. [22] have argued for the inclusion of further futures studies-led methods in HCI. While such interaction ideation methods are common in developed world commercial and research settings, very little work of this sort for emergent users has been reported. In [33], existing technologies (e.g. digital cameras and payment devices) were used in workshops to explore issues of technology viability and adoption in specific domains. With more broad aims, Jung and Chipchase [20] report on a competition in 2007 in shanty towns to design residents' "dream" or "ideal" phone. In this paper, while we similarly use prompts and probes and ask our participants to sketch devices, we do so with a more diverse set of emergent users, probe a further-out future, and seek insights that go beyond the "phone", exploring interaction and interface styles rather than simply functions and features. Furthermore, as we explain below, we do so with an orientation that seeks long-term active shaping of technologies by the emergent groups we encounter [4, 19].

It is important to note that we are not arguing that all developed world users per se are engaged in shaping technology design; nor, that innovation and inspiration is not already flowing from developing regions. As one reviewer of an earlier version of this article noted, users in Bangalore might be more involved in shaping technological trends than someone in the rural Midwest of the USA and there have been important platform inventions such as mPesa from Kenya. However, there are many studies reported in journals such as PUC or conferences like CHI that involve developed world users in future-focused studies; meanwhile, by contrast, there is a paucity of such work that engages with emergent users.

3 Sustained engagement with emergent user communities

The work reported here is part of a three-and-a-half year engagement involving researchers from each of the three regions of interest (South Africa, Kenya and India), local researchers from the emergent communities we are working alongside, and others from outside of these regions.

Each year of the project begins with a Summit in one of the locations (in the year reported here, this was Bangalore) to which a range of stakeholders were invited including an inter-disciplinary mix of industry, NGO and academic researchers, developers and designers. Prior to the Summit, the design workshops with emergent users, reported here, were conducted in Bangalore, Cape Town and Nairobi.

The insights and ideas created by these participants were used as input to the Summit. Summit attendees then proposed a series of potential future devices, platforms and services. These responses to the emergent users were taken back to the groups, after the Summit, for discussion and refinement.

All of this activity took place over a 2-week period. Following this, given the input from the emergent users, we have been developing working prototypes that have been taken to user groups in South Africa and India, with a third visit—to Kenya—scheduled for mid-2016, to gather further refinements. Later in the year, the prototypes will be deployed over a longer period in these contexts.

4 Participatory design workshops: imagining digital interactions in the far-off future

Focusing on the Summit period, five co-ordinated design workshops were convened in three countries. Each session lasted between an hour and an hour-and-a-half, and involved researchers and local partners who could speak the language(s) of the participants. All researchers in each of the locations are authors of this paper.

4.1 Participants

We recruited 54 participants in Bangalore, India; eight in Langa, a township in Cape Town, South Africa; and nine from areas around Nairobi, Kenya. The higher number of participants in India was a function of the Summit location (Bangalore): we wanted to ensure there was a particularly strong voice from Indian emergent users given the majority of Summit participants were from this continent. In future Summits (in South Africa and Kenya) we aim to see a similarly increased number from these regions.

We selected participants who had the following backgrounds: low personal and/or family educational attainment and literacy; no or low personal exposure to advanced digital technologies (such as mobiles with substantial processing power, memory, sensors and actuators; PCs; internet or data connections); and low incomes (see Table 1). We worked with local contacts in each location to identify participants, asking these partners to recruit people who would be described as emergent users.

The groups we worked with spanned generations (from young school children to 65-year-old female domestic workers) and varied in the level of "resource constraint" (e.g. some earning relatively more than others, as detailed

Table 1 Overview of study participants in each workshop location

Location	Participants	Ages	Literacy	Technology exposure	Data connectivity	Income
Bangalore, India	16 domestic workers (all female)	35–65; avg.: 51	None	Low: mostly basic or featurephones, one touch screen; no access to computers	None	$60–$90/month
	8 auto-rickshaw drivers (all male)	45–65; avg.: 49	None	Low: 6× featurephones 2× basic phones; no access to computers	None	<$20/day
	30 after-school club members (24M, 6F)	9–19; avg.: 14	Literate in Kannada; oldest some English	Medium: access to PCs at kids club; one older member had a smartphone	Internet only via club PCs (when permitted)	n/a
Cape Town, SA	8 Langa residents (4M, 4F)	18–44; avg.: 29	Literate in isiXhosa	Low: all owned featurephones; no access to computers	None	Low (all unemployed)
Nairobi, Kenya	9 local residents (4M, 5F)	19–29; avg.: 22	Literate in Swahili; some English	Medium: 3× smartphones, 3× basic phones, 1× featurephone, 2× no phone	Some access on phones (3 people)	Low incomes (<$140/month)

Participant groups encompassed a wide range of ages, and literacy and education levels, but all had low exposure to technology, low income, and were identified by our partners as being emergent users in their region

below). It is important to design in terms of such spectrums of constraint and availability. It would be much less fruitful, in contrast, to approach the problem in a discrete way (e.g. "design for illiteracy") as not only will a user's ability vary over time, but they will live in a context of friends, family and co-workers who might well differ from them but who will support their use of new technologies.[1] All of our participants, though, shared the characteristic of not being the target end-users for current mainstream smartphone devices, and for whom a standard smartphone proposition would be less valuable than it might seem (e.g. due to the devices' textual and computer-centric interfaces; unaffordable data plans; or lack of apps or services perceived as of use and value to them).

All participants also had a high degree of mobility in their everyday life—with the domestic workers moving from house-to-house and within the houses they were cleaning; auto-rickshaw drivers covering many miles in the city each day; schoolchildren walking extended distances between home, school and an after-school club; and the Cape Town and Nairobi participants often commuting in shared minibus taxis to and from their work or social locations.

4.1.1 Bangalore: domestic women workers' collective

We met with 16 domestic workers at the office of Stree Jagruti Samiti—a female domestic worker's collective—and were joined by four NGO employees who have been working with them to find ways of increasing job rights. Ages ranged from 35–65 (avg.: 51) and through their cleaning and house chores each person earned between ₹4000–6000 ($60–$90) per month. The women worked for multiple clients everyday, cooking and cleaning for 5–6 h, daily. Most started work at the age of ten and have worked continuously since then. The NGO founder explained that women like our participants were "vulnerable in many ways" as their work has no regulation, no structure, and many are subject to sexual harassment and domestic violence. Ninety per cent of Indian women work in such an unstructured context [26]. The NGO is working with the women to provide structure, rights and a safe space. The participants' stories and design ideas—as we will see later—bore out the reality of such a working environment.

In terms of technology, most of the group owned phones, and we observed a range of basic and feature mobiles, and one touch screen. Predominantly, these mobiles were used only for calling (but the touch screen user took photos for local use). On average, the women spend ₹100 ($1.50) per month on their calling plans, in ₹30–40 ($0.50) increments. The women are often not allowed to use their phones while working (but their employers want them to have phones in order to contact them).

This group was particularly interesting to us because of the possibilities that mobile and other technologies might provide in supporting them in their highly mobile and flexible employment, and in helping them collectively organise in what can be a very isolating working environment.

4.1.2 Bangalore: auto-rickshaw drivers

We met with a group of eight male auto-rickshaw drivers in a leafy park in Jayanagar, Bangalore—one of the places the drivers socialise at after work. The workshop was

[1] For instance, in India, approximately 24% of the population are illiterate; a further 25% have low literacy (<5 years of schooling), and 25% literate without English exposure (<8 years of schooling).

facilitated by an employee of three Wheels United, an NGO focused on providing finance to drivers to purchase their own vehicle.

Drivers were aged between 45–65 years old (avg.: 49), with no literacy (except the ability to recognise street names on texts or signs). The highest daily earner was ₹1500 ($20), but the majority of the drivers earned far less than this. The workday varied in length depending on business, but generally lasted for 4–12 h/day for six-and-a-half days each week. All of the drivers owned their rickshaws through the TWU scheme, with the cost of the vehicle being approximately $2300.

Six drivers owned feature-phones, and two had basic phones. None of the drivers had smartphones (the NGO employee said they were "not ready for it yet"). Mobiles were used primarily for making calls, but rather than using the contact list, phone numbers are memorised, or a driver will ask a colleague. One driver (the highest earner) had a second featurephone provided by Ola (Ola being the Indian "Uber"). Assignments come through as text messages with pickup details; as the driver can not read these, he calls the passenger to clarify the location.

Rickshaw drivers like the ones we worked with were valuable participants, not just because they are members of our core user group, but because they meet and interact with hundreds of passengers each week drawn from many walks of life, from the very poor to the highly affluent; and they are exposed to all aspects of the bustling city life, picking up and dropping off passengers in places as diverse as slums and luxury hotels. Furthermore, though not formally educated, drivers are often tech-savvy enough to repair their auto-rickshaw in a pinch and may even help others out if their cars break down, sharing the repair skill and perspectives, then, of [20].

4.1.3 Bangalore: after-school kids club

We ran a workshop at CLT India's Computer Clubhouse, meeting with around 30 children and young people (6F, the rest male, with an average age of 14 and a range of 9–19 years). The children were from low-income families (with parents who had occupations such as driver or manual worker and who had much lower educational attainment than their children). All of the children had good literacy in their local language (Kannada), and several of the older children had a working knowledge of English. The club meets every day after school, in a self-help format, learning computer skills such as creating graphics and drawings with PC packages. We were interested in working with this group because they understand and live the life of an emergent user; *and*, were motivated and enthusiastic to the possibilities presented by digital innovation.

4.1.4 Cape Town: Langa residents

At the same time as the workshops in India, we also ran a session in Cape Town, South Africa. Working with a community facilitator, we convened a group of 8 participants (4F) in Langa, a township outside the main city. Participants ranged from 18–44 years in age (avg.: 29). The highest educational level of most participants was high school (leaving school aged 16–18). All were unemployed (and looking for employment), and their exposure to advanced digital technology was low, with seven having no access to a computer (the other person only at a library), and six never having used a touch screen. All participants owned a featurephone.

We were interested in working with these community members because of their lack of prior direct hands-on exposure to advanced digital technology. We wanted to explore what they would design without such influences that would also fit with their life skills and financial situations.

4.1.5 Nairobi: local residents

In this case, participants were from low-income areas within Nairobi (primarily Kibera—the second largest slum in Africa—and Uthiru). Nine people (5F) aged 19–29 (avg.: 22) took part in the workshop. All had low incomes, with the majority self-employed or doing casual shift work when available. Seven of the participants were educated to high-school level, while one was educated to primary school level and one had started college (but had withdrawn due to lack of funding). Some participants could speak English with difficulty, but all were literate in Swahili (the local language). Three had smartphones, three owned basic phones, and one owned a featurephone. The others did not own a phone.

Nariobi is widely recognised as a technology hub with a growing community of digital innovators and start-ups. Involving participants from this city, then, was seen as highly important to our study, as they are exposed to a vibrant, fast-changing digital landscape.

4.2 Method

Before the workshops, we held discussions with partners in each region to shape activities that were seen by these stakeholders as being appropriate and valuable. The Ethics Committee at the organisation leading the project work also reviewed and approved the study plans.

The same workshop method was used in all sites. After introducing the research team and explaining the range of questions and activities we were interested in, participants were asked whether they wished to take part, and gave

consent for us to use their input for research purposes. Participants consented orally to taking part and to having their images and work published academically.

We asked participants to take part in two envisioning activities. In the first one, they were placed into small groups of 2–4 people and asked to draw a picture of their ideal mobile device that they might own in the "far-off future", defined as 5–10 years from now. They were told that they were free to design it so it had any shape, size or material they liked. We based the technique on that developed by Jung and Chipchase (cf. [20]). Participants took approximately 15 min for this task, and when completed we invited teams to present and discuss their ideas with the group.

The second task involved a "magic thing" [18]. One of the researchers wore a simple fitness band on their wrist and explained to the participants that it was a "magic thing"—that is, it could be or do anything the user wanted in terms of how it helped them communicate with others, access content or provide information and answers to their needs. Participants were then asked to work in teams to specify what they would want the magic thing to be and do if they owned it in the far-off future. After around 15 min, teams were invited to act out their design scenario to the group while wearing the magic thing.

Participants were compensated in various ways depending on individuals' and groups' preferences. The auto-rickshaw drivers were paid ₹500 ($8) per person, whereas the domestic workers preferred a group donation to the collective (₹8000), and the after-school club group wished to participate without an incentive payment. The Cape Town and Nairobi participants were given R150 ($10) and KSh700 ($8) each, respectively.

Workshop interactions and outputs were captured using video and still cameras along with notes taken by the researchers. After each workshop, the researchers in each workshop were asked to independently analyse the outputs to identify key insights and themes. These were then discussed and refined in group sessions (with the researchers in Kenya and South Africa connecting to the larger Indian team via Skype meetings).

5 Key insights: mobiles of the future

5.1 Bangalore domestic workers' collective

For the domestic workers, a strong desire was for their future mobile to be hidden (or hideable) but accessible. This need was motivated by both safety concerns (they did not want their device to be stolen) and the fact that their employers might become angry if they saw the women using a mobile. The women's suggestions included wearable mobiles in the form of jewellery (e.g. see Fig. 1 (left) with a ring-based mobile; another example—not shown—involved a necklace device that could be subtly hidden in the folds of a sari), and earpiece devices that automatically answered calls or provided spoken content without others being aware of the interaction. One lady suggested hiding the device in a hairbrush: she explained that as she pretended to brush her hair, she could listen to a call from her husband as well as talk to him.

Wearable designs dominated the discussions and drawings. As well as the earpiece, rings and necklaces mentioned above, there were also pendants and bracelets. The ladies in the workshops all wore many items of jewellery, from ankle bracelets and toe rings to necklaces and earrings, as is the norm in India. They saw future mobiles as being an additional adornment—becoming part of their identity—and mentioning too the importance of personalisation (such as colour choices).

Many of the designs illustrated a desire for simplified interactions. Given the lack of literacy in the group, it was perhaps not surprising to see examples where images for notifications and functions were preferred over textual menu items: for instance, one team suggested a watch-like mobile that showed a symbol to represent the message sender ("a jackfruit for Jack"). There were also requests for fewer or larger buttons. It was interesting, too, to see the simplification agenda played out via appliance design thinking in these non-technical, non-design trained participants. One team, then, requested a ring-type device that took a picture whenever pointed at someone [see Fig. 1 (top left)]; another, a device that rang and showed the camera picture when a friend was in trouble (this device was motivated by the violence often suffered by workers); and a third, an earpiece device that could act intelligently such as saving a number mentioned by the caller for future use.

Gestural and natural style interactions were discussed by many teams, ranging from the previously mentioned hairbrush and ring-pointing to a wearable glove-like device [see Fig. 1 (bottom left)] that combines gestures and elegant simplicity. The lady who designed this mobile explained how she wanted to simply point a finger to call one of five key contacts (such as the police). Finally, many of the teams mentioned the need for devices with a long battery life that were not too heavy.

5.2 Bangalore auto-rickshaw drivers

The form factors sketched by this group were more conventional than those created by the women, with all being based on the familiar oblong shape. The group focused rather on thinking about future services. Figure 1 (centre)

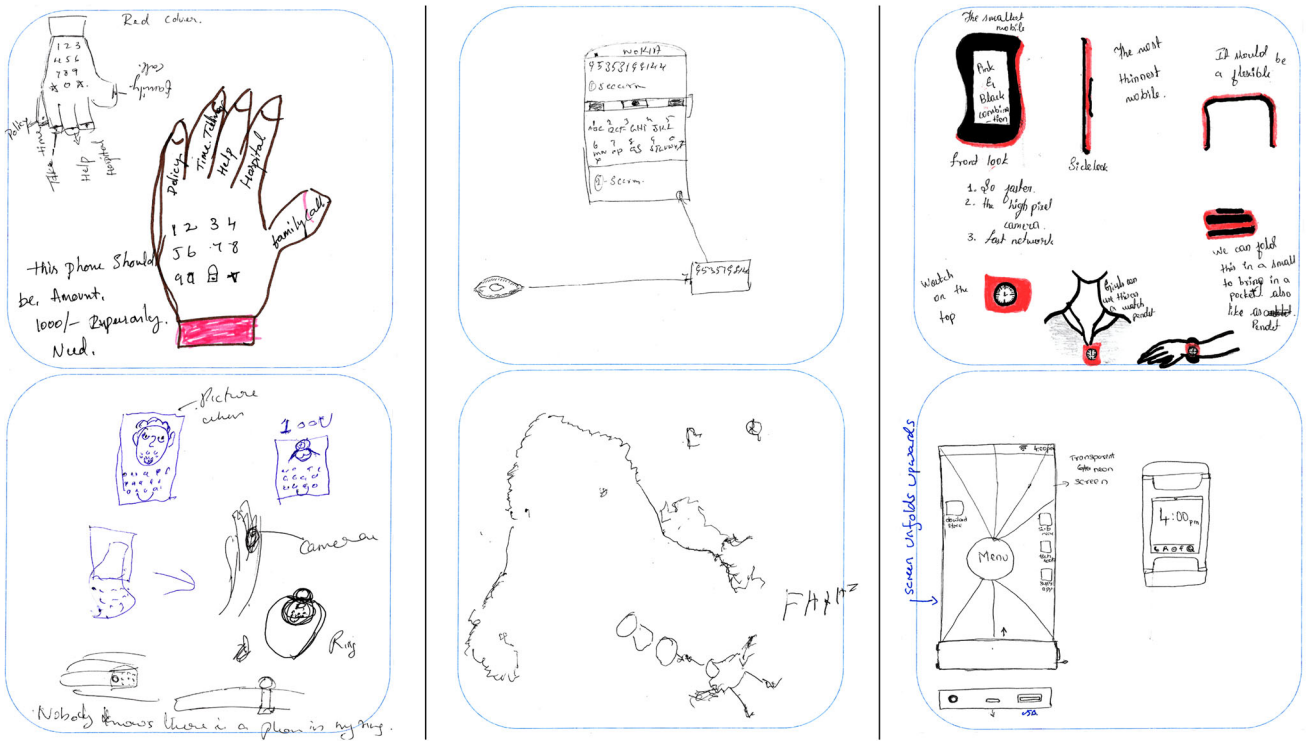

Fig. 1 Example sketches drawn by participants in Bangalore. *Left* sketches by the domestic workers. *Centre* sketches from the auto-rickshaw drivers. *Right* sketches by participants in the after-school club. After-school club members made 16 sketches in total; other participants made one per person. English annotations on the domestic workers' and auto-rickshaw drivers' illustrations were made by researchers in discussions with participants

illustrates two of these. In the first (top centre sketch in Fig. 1), the driver explained that he wanted a device with a split screen with the bottom display showing content (such as telephone numbers or advertiser offers) that he had looked at while driving through the city. The drawing illustrates the interaction with his "eye" looking at content and this then appearing on the lower screen.

The sketch at bottom centre in Fig. 1, meanwhile, is a driver's map of difficult roads and junctions he has to traverse. He wanted the phone to be aware of his location and driving conditions so that it would stop working when he needed to be more aware of his surroundings. This context-aware suggestion should be seen in the light of urban Indian driving conditions (which are normally chaotic and busy compared with many, say, Western cities) and styles (e.g. drivers are often engaged in energetic phone conversations while navigating densely packed roads with no lane discipline).

5.3 Bangalore after-school club

Conventional oblong form factors were also seen in many of the sketches from after-school club participants, though there also several pendant sketches, and one eye-wear based device.

The work of two of the groups stood out in terms of their material form [see Fig. 1, (right)]. The first (top right) considered the possibilities of a highly flexible device that could be folded and shaped into different small form factors to be worn or carried more easily and safely, reducing theft. The second group (bottom right) had a design that was also motivated by a desire to conceal and increase the portability of the device. In this case, the main body of the mobile was described as a pen-like device from which a flexible screen could be unrolled.

Several of the other groups wanted their future device to be able to connect to other larger input and output devices (with their sketches showing, for instance, large keyboards attached to some input port, and output ports for connection to a TV).

5.4 Nairobi

For this group, participants talked of how their daily life might easily bring them into situations where they could experience theft or aggravation, and this is reflected in their designs. Safety and personal well-being features were a key concern, then, as Fig. 2 (top left) well illustrates. The notes for this sketch explain a novel way of tricking an onlooker into thinking the device is being held when placed on a

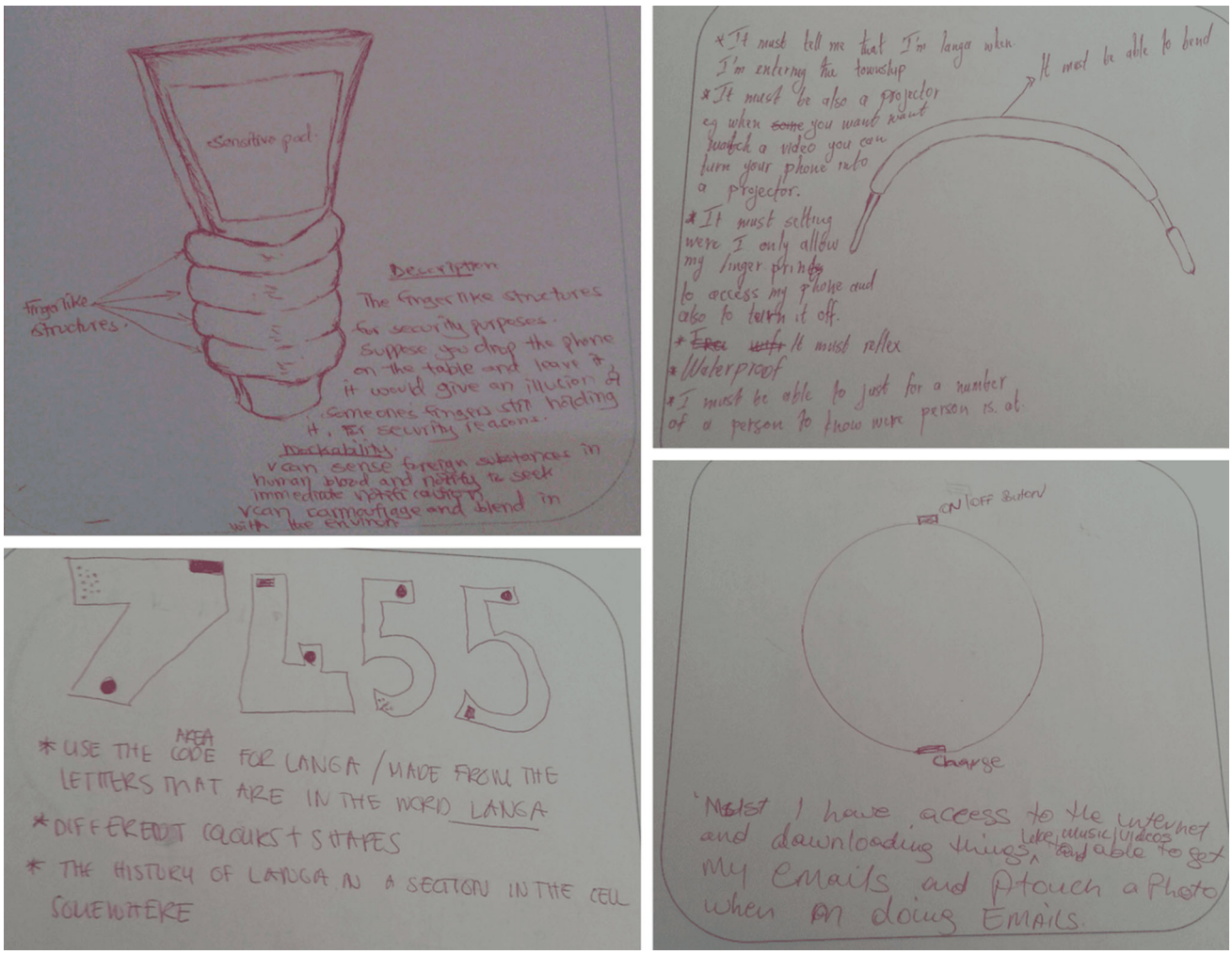

Fig. 2 Future mobile sketches from participants in Nairobi and Langa (Cape Town). In most cases, annotations were added to the drawings by researchers during discussions with participants. *Top left* a sketch from the Nairobi workshop. Note the fist around the device—this is a security feature, tricking onlookers into thinking the user is holding onto the phone when it is put down. *Other images* four sketches by Langa residents. Half of the designs in Langa were in non-conventional form factors. The mobiles ranged from a set of components in the shape of the Langa postal code (*left*), to circular or flexible devices (*right*), and one that remained in a pocket at all times

table, make a further suggestion about the device camouflaging itself, and discuss including a pad that can analyse the blood of a user to provide medical warnings. Another participant wanted their future mobile to be able to alert them about upcoming dangers ("such as riots and fires").

The group had an extended discussion around conversational interfaces—they wanted to be able to talk to the device "as a friend", even to the extent that they suggested that if the device recognised they were praying, it would "pray along with them". Voice interactions, as in this example, were seen as important. One participant wanted a voice-based interface but wanted it to work with their "slang" rather than conventional, accepted language. More prosaically, the group also discussed the problems of recharging their phones during the day and suggested devices that could incorporate solar or "body heat".

5.5 Cape Town

Half of the designs from participants in Cape Town were unconventional (e.g. non-oblong shaped), with some examples shown in Fig. 2. There were circular forms, bracelets and small—easily carried—matchbox-sized suggestions. One participant (whose sketch is top right in Fig. 2) spoke of a device that could change form factor to provide different functions and which was physically flexible. While a number of the participants mentioned brands in their descriptions (mainly "Samsung" and "Nokia", reflecting the domination of these manufacturers in the region currently and historically), there was a desire to see future devices that reflected their pride in where they came from. The most striking example of this was the set of phones shown in the bottom left sketch in Fig. 2. Each device is a number from the postal code for Langa

(the notes also suggest phones in the shapes of the letters in 'Langa'). This participant also wanted the phone to have "the history of Langa in a section in the cell somewhere".

Like the Nairobi participants, Langa residents live in locations with relatively high rates of theft. Their designs also reflected this, with several suggestions of a device that could be left in a safe place (e.g. at home) but still accessible via a smaller module while away; or having a form factor (such as being very thin) that would not attract a thief's attention. In a similar way to the auto-rickshaw drivers in Bangalore, several participants mentioned context-aware services (such as information about their current location or the location of their friends); like the children in the after-school club, there was a common desire to be able to connect their future mobile to or create larger output displays (such as the top right sketch in Fig. 2, where the participant wants the phone to be able to "turn [...] into a projector"); and like the women's collective, there were suggestions for non-textual interactions (such as sending an email by "touch[ing] a photo when doing emails").

6 Key insights: the magic thing

6.1 Bangalore domestic workers' collective

Security and connections to friends and loved ones were two recurrent themes for this group during the activity. One group, for example, explained how when they are abused, the police often dismiss their complaints. They wanted the "magic thing" to automatically record incidents where their employees abused them to use as evidence to the authorities. Another suggested the bracelet would give them a continuous sense of being in touch with their partner or friends. Many of the women wanted the device to reduce the physical burden their work places on them: "I visit 5–6 houses every day—that's [sic] lot of chopping. My fingers are ragged [...] point the magic device and get everything done".

6.2 Bangalore auto-rickshaw drivers

The drivers also discussed the way the magic thing could help them connect to their family, with one example being a way of summoning their children home—a tap on the device would guide the children to the father's location. Picking up on the desire for mobiles to be part of an ecology of devices—as discussed by participants in the first activity—one driver acted out the bracelet's role as a movie selector for display on another screen. He gestured at the bracelet to choose a film and then pointed at an imaginary display to watch.

6.3 Bangalore after-school club

While many wearable devices currently deployed in the developed world are about monitoring the status of the wearer (e.g. their activity levels), several of the teams in the after-school club suggested ways the magic thing could give them insights into other people—"point it a person and get a sense of their mood"; "point it at others and get their vital signs"; and "point it at someone to read their mind".

One team wanted the bracelet to be a dance tutor. They explained that you would speak the dance style you wanted to learn (e.g. classical) and then the bracelet would "control you", leading you in the moves and giving feedback or making corrections as you made them. Interestingly, a technology that relates strongly to this idea was recently published: here a walker can be directed through subtle muscle stimulation [32].

6.4 Nairobi

The magic thing probe stimulated much discussion in this group focused on wearables to enhance personal emotional wellbeing and health. Several examples included bracelets that could check the individual's health status and provide advice to improve fitness. One group also suggested clothes that could function in this way, with an example being socks that monitored the amount of walking done by the wearer, warning them to take a rest if they had been too active. This is an interesting twist on the quantified self, where in the developed world people use devices to nudge themselves from their sedentary lifestyles to do *more* rather than *less* exercise.

6.5 Cape Town

In Cape Town, the probe elicited few comments on what such a device would do, but more on the value of such form factors and how the participants would like to interact with them. Participants said they liked the idea of wearable devices as they are more secure, especially in unsafe areas. In addition, they indicated that the device should be able to be hidden under clothes in such places.

Participants went on to give examples of the sorts of wearable they would see as potentially acceptable, including devices like rings, earphones and necklaces that are discreet and non-obvious, and may not attract unwanted attention. While acting out use of the wrist device, most of the participants interacted with it through tapping on it. Some also indicated that the device should also respond to the user looking at it.

7 Discussion

7.1 Working with emergent users on the further-out future is valuable

Some previous work in developing region contexts has suggested that asking non-expert end-users directly for their views on future technologies for specific use cases (e.g. in healthcare) is problematic, with mediated insights such as those seen in previous phone-repairer studies (e.g. [20]) as being likely to be more fruitful [23].

Our work, though, indicates that those interested in future technology envisioning for emergent contexts should not limit enquiries to such 'expert' community members. The participants in this study did not have any technical expertise in phone technology or interaction design. Indeed, while most of these participants had very simple devices with limited forms of services, many articulated their future designs in terms that resonated strongly with sophisticated interface and interaction concepts and paradigms. These included appliance design, context-sensitive interfaces, gestural interaction, natural user interfaces, conversational interfaces, mutable devices and the value of modularity.

Like the earlier phone-repairer studies, our participants also suggested some sensible improvements to mobile phone specifications (e.g. extending battery life), but went further by providing insights into interface and interaction styles. These discussions were facilitated by purposely asking our participants to think further into the future and not to limit their thoughts to current mobile phone forms and styles.

We believe that an additional value in asking emergent users about their further-out future use of technology is that it can give insights into what they feel is likely to be the same in the future, and what is likely to change, in their wider experience of life. We did not encounter comments that indicated that such technologies were out-of-reach from our participants' perspectives. There was an expectation that in the future, advanced devices, services and data connections will be available and affordable. This is certainly not the case now. Meanwhile, the emphasis on non-textual literacy and security concerns indicates that our participants do not envisage their world being free of some of the limitations and difficulties they currently experience (such as lower educational attainment). Of course, there will be improvements, but the designs our participants developed remind all of us that smart technology does not alone lead to better life chances and experiences.

7.2 Pointers towards future mobiles for emergent users

Firstly, all of our groups showed enthusiasm and innovative ideas concerning features and form factors for wearable and easily carry-able devices. It is not yet clear whether devices like smartwatches will become all pervasive in regions—such as the UK and USA—where smartphones are dominant. It might be that the more mobile character of lifestyles such as those of our participants, allied to security concerns, will make such devices more attractive in these contexts.

Participants wanted devices that were designed with an eye to personal security—they should not put the user at risk and should reduce the chance of theft. Devices that blended visually with their owner were discussed, from wearables that could be hidden in the folds of a sari to a chameleon-like device that automatically camouflaged itself.

Many designs across the three regions raised the need for peripherals and services that could make their future mobiles more usable and valuable. These ideas remind us, as Donner and Walton [11] do, that while the mobile is an important technology for developing world contexts, users in these regions, as users everywhere, do not want to rely solely on their small screens and restricted input devices all the time.

In developed regions, the percentage of time users spend using spoken or gestural features of smartphones is very low compared to textual and graphical manipulations. Our emergent participants' designs, in contrast, had many examples of these "natural" user interfaces, driven by both literacy issues but also context of use ones. Consider again, then, the hairbrush interaction of one of the domestic workers, or the hands-free glance-based information gathering of the auto-rickshaw driver.

The examples of how the domestic workers are concerned that having a mobile phone would symbolise their attention to the present highlight how their design needs point towards profound sociostructural matters. In developed regions, the capacity for what Goffman [15] called 'civic disattention' is now supported and made commonplace through the ways people use their mobile phones to disattend to those they are with. But their capacity to do so is bound up with their social rights to be disattentive; those they are with have little power over them. For emergent users, this is not the case; design for 'perpetual contact' (as put by Katz and Aakhus [21]) needs to be alloyed with more sensitive designs which allow contact that is discreet. Here the design ideas that were articulated by participants point towards elaboration of Donner's "call me back" studies (cf. [10]). They evoke too the way that the visual can be used to create a currency of meaning and co-presence, as described, for example, with the use of Glancephones [16].

Conventional smartphone designs have simply evolved how early featurephones could be used to demonstratively display the connectedness of the 'flaneur,' as Fortunati and

others explain [6]—with today's iPhones, as a case in point, being as much devices to show disattention to the co-present other, as attention to the remote party. They are, then, technologically embodied 'statements of rights' that assert how the owner can respond to a remote other as and when they see fit. Developed regions' wearables similarly announce and symbolise especial connection to some remote other. In contrast, the design proposals that allow technology to nestle into and ornament the everyday—but identity stating—dress produced by these participants point to devices that might preserve their sense of commitment to the present, to the local other, and to the social context and arrangements within which they have to operate.

All of the workshops illustrated the desire of participants to own and use future technology that they would enjoy and have pride in. On one level this was evidenced by participants expressing their hope to own an Apple or Samsung product, with some of the sketches having such high-end brand icons. Also remarkable is the absence of any of the Indian and Chinese brands that are in fact more popular in these markets. This either points to multiplicity and non-differentiation in these brands, copy-cat use of trademarks, or their being seen as affordable, and hence perhaps down-market (and less futuristic). It was also evident, though, in the value participants placed on features that they and people in their social group would see as advanced and modern. As they explained some of the more futuristic designs, their engagement in explaining the "wow" factors to the researchers and other participants was highly visible. Finally, several groups raised the value of physical and interaction designs reflecting local cultures and personal identities that mattered to them (e.g. the domestic workers seeing wearables as additional adornments, and the Langa residents wanting designs to remind them of their township in both form factor and local content). Developers of future smartphones and mobiles, then, should not simply focus on constraints and limitations found in developing region contexts. Doing so may well provide a rugged, power-efficient and simple-to-use technology but one that will be have limited appeal, being seen as the "poor user's" phone [7].

Productivity apps and services (like mobile email and time management) are important to developed region users. While the comments by one of the domestic worker participants ("[...] that's [sic] lot of chopping. My fingers are ragged") are reminders of the hard working conditions of these and many millions of emergent workers—conditions that will need much more than digital interventions to alleviate—they also point to the potential for productivity supports in these difficult contexts for our participants.

While there were such commonalities between the ideas coming from India, South Africa and Kenya, it is important to note that there were differences in the specific details and motivations of the designs: for example, in many there was a desire for discreet interactions. In some cases this was motivated by security; in others by privacy, and the articulations varied from hiding interactions in jewellery to ones that enabled a large device to be left at home while a more discreet component is carried. Furthermore, there were distinct designs from each region. Our findings suggest that emergent users are more different from each other than the first adopters. An engineer or a doctor or a banker might be considered to have similar needs, abilities and outlook everywhere in the world, and thus could use the same apps. In contrast, the preferences of an auto-rickshaw driver, a domestic worker or a farmer in one part of the world could be very different from their counterparts elsewhere. These users may often need more differentiated products than "top of the pyramid" consumers, then.

7.3 Transferring ideas to the rest of the world?

The experience in working with "last-adopters" such as the participants of the studies reported here suggests the approach could be extremely fruitful in innovating for developed regions. So, while wearables and spoken interfaces are just another "feature" for tech-savvy consumers, as we have seen, for emergent users they could be more integrated in their lives. Talking with people who are highly motivated to see useful devices and services with such features can drive more imaginative innovations for users worldwide. Furthermore, their ideas come fresh, free from first-hand experience of other advanced technologies, and un-encumbered by notions of what is possible. Indeed, many of these ideas are not just potentially realisable but share visions with expert researchers in, say, the CHI community (see the earlier discussion relating to [32]). For us, then, the workshops with emergent users stimulated several ideas for rest-of-the-world service innovation, including the following. We present the ideas here not to suggest these are the only starting points the work suggests, but to stimulate others to engage with our data and to carry out further studies with this lens.

7.3.1 Un-noticeable interactions (drawing on the Bangalore hairbrush device, and camouflaging notions in Nairobi)

What can we design to give users the benefits of digital services without appearing rude or anti-social when co-located with others? Our participants' designs stimulate two new ideas that go further than previously reported work (such as [3, 12]). Imagine a mobile that disappears from view from everyone except the owner—the 'chameleon' mentioned by one of our Nairobi participants. It effectively dissolves into the table it is placed on; or into

the hand it is being held in. Alternatively, what would be the value of presenting notifications and allowing responses during natural gestures with a device, inspired by the hairbrush mobile seen in the domestic workers' group? For instance, a smartwatch interface could use the gestures of the wearer's hands during a conversation to show them information; or seek input without disrupting the flow of the chat or forcing them to purposefully glance at the device.

7.3.2 Mobile speech interfaces that go beyond utility and simple task completion or question answering (drawing on the Nairobi prayer companion and slang notions, and the ambient earring and dance bracelet in Bangalore)

The value of spoken interfaces in mobiles for developed region users is still under debate [28]. The designs from the Nairobi groups concerning a prayer companion point to a potentially fruitful direction for speech input and output that might see wider adoption of this modality. Instead of simply looking at what can be done more effectively on the screen and through direct manipulation, developers and researchers should be focusing on non-transactional conversational interfaces. By this, we mean services which can engage with a user as a "friend or companion", in the words of one of the participants. Such reframing of spoken interaction might lead to greater advances than the predominant focus on transaction- and goal-directed interfaces of today's speech interfaces. The potential for more humane speech systems has been recently demonstrated in *XiaoIce* [42], a conversationally styled chatbot that Microsoft recently introduced to China, and which has become incredibly and increasingly popular.

7.3.3 The quantified "other" and mindful interactions (drawing on the magic thing examples in CLT, Bangalore, and sketch designs from the domestic workers)

Several of the examples of future devices and services from the after-school club workshop described devices that would allow them to find out about others. That is, instead of focusing on the "quantified self" they wanted to have platforms for the "quantified other". The value of exploring services and interface styles that promote such communication and connection with others that is mindful of their context has only recently begun to be argued by others in the research community [34]. Such a reorientation from the mobile user at the centre of an interaction to the "other" being the most important is a significant one, as discussed earlier.

8 Conclusions

Emergent users have been the focus of many mobile social development and research study projects over the last decade. The emphasis has been—rightly—on exploring the use of a pervasive technology, the mobile phone, in improving health, finance, education and community resilience in contexts where there are normally low socio-economic and education opportunities.

In this paper, though, we argue that it is now time to engage with such users so that they can help sketch out a longer-term technology road-map that will lead to devices and services which will be of value 5–10 years from now. The value of such an approach has, we believe, been illustrated through our engagements with the five groups of users in India, South Africa and Kenya that we report on here; engagements and encounters that are part of a multi-year programme of study. Despite their lack of familiarity with advanced technologies and any exposure to design-thinking or activities, our participants created stimulating designs and insights. Furthermore, their sketches, scenarios of use and discussions present challenges to the orthodox directions—and framings—seen in today's mainstream mobile services used in the rest of the world.

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