Diversifying Future-Making Through Itinerative Design

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"Designed in California" is a brand statement used by high-tech manufacturers to denote provenance and cachet of digital innovation and modernity. In this paper, we explore philosophically alternate design perspectives to those this statement embodies, reporting and reflecting on a long-term multi-sited project that seeks to diversify future-making by engaging communities of "emergent" users in "developing" regions. We argue that digital technologies are typically created with a design lens firmly focused on "first world" populations, assuming a base set of cultural norms, resource availabilities, and technological experience levels that do not strongly align with those of emergent users. We discuss and argue for inclusive technology design methods, present our approach, and detail indicative results and case studies as an example of the potential of these perspectives in uncovering radical innovations. Distilling findings and lessons learned, we present a methodology—itinerative design—that pivots between emergent user communities across multiple regions, driving digital innovation through the periphery of mainstream design's current remit.

CCS Concepts: • **Human-centered computing → HCI design and evaluation methods**; **User studies**; **Interaction paradigms**; **Ubiquitous and mobile computing design and evaluation methods**;

Additional Key Words and Phrases: Itinerative design, future-making, co-creation, emergent users

ACM Reference format:
Jennifer Pearson, Simon Robinson, Thomas Reitmaier, Matt Jones, and Anirudha Joshi. 2019. Diversifying Future-Making Through Itinerative Design. *ACM Trans. Comput.-Hum. Interact.* 26, 5, Article 33 (July 2019), 21 pages.
https://doi.org/10.1145/3341727

1 INTRODUCTION

"Designed by Apple in California." This statement is boldly etched into the back of the iPhone, a computational device that over the past decade has brought about a sea-change in how many of us live our everyday lives. The statement emphasizes how computer engineers, information architects, business strategists, interface designers, and a myriad of specialists have come together, in Silicon Valley, to shape some of our most common everyday experiences: how we interact with our smartphones and with each other through their mediating influence.

This work was funded by Engineering and Physical Sciences Research Council Grant EP/M00421X/1 (https://www.reshapingthefuture.org/).
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1073-0516/2019/07-ART33 $15.00
https://doi.org/10.1145/3341727

Although *Designed in California* is unique to Apple's brand, the practices of that slogan resonate across the Silicon Valley at Google, with its Android operating system and comprehensive cloud offerings, and Facebook, which recently surpassed 1.5 billion daily active users on its social network. The slogan, to be sure, is clever branding, but the rhetoric that surrounds it also articulates what Suchman refers to as, an *"attendant mandate to enact the future that others will subsequently live"* [49, 2].

Not represented in this model are the places and workers that assemble our computational future, for instance in Shenzhen, China [22]. Nor do we intend to discredit vernacular forms of design-in-use, creative appropriations, and adaptions of technologies, and the efforts required to keep things going in the same way [48]. To the contrary, we celebrate and are inspired by these! Alternative practices of technology production, such as those articulated by DIY, maker [5], and repair culture [41], are likewise laudable alternatives. Despite these efforts, however, and without falling into the trap of technodeterminism [14, 34], we remain weary of the fact that a globally unique center of technological innovation holds an inordinate amount of influence across the world. After all *"technologies designed at a distance,"* as Suchman reminds us, *"are characterized by a design/use gap that requires either substantial reworking of the technology or, if that is impossible and prospective users are powerful enough, its rejection"* [48, 143]. In our work, we seek opportunities for disruption and relocation from these *dominant* forms of technological innovation and future-making.

To further this aim, we are inspired by Agre's critical technical practice (CTP) [2], but instead of inverting dominant metaphors of a technical field, we seek to recognize and invert the location and one-size-fits-all mindsets of its dominant information flows and innovation practices, which re-produce neocolonial geographies of centers and margins [49]. While we deviate from Agre's approach in this respect, we remain committed to his insight that CTP requires a split identity with *"one foot planted in the craft work of design and the other foot planted in the reflexive work of critique"* [2]. That is, to drive mobile innovation not from within its traditional center, but along its current periphery, addressing a simple question: *whose future is it?*

This is a question that has motivated our long-term multi-sited project to engage communities of "emergent users" [12] in the design of future technologies, creating opportunities to co-create, shape, and refine devices and services based on their own needs and desires, just as more traditional technology end-users, located closer to design's traditional centers, have done for many years. Our approach involves developing and sustaining a close relationship between a core project team and groups of emergent users over extended periods of time (4 years to-date), refining and testing ideas, probes and deployable prototypes in-situ throughout the process. The aspiration is to uncover fundamental, generally applicable interaction and transaction techniques for use in a diverse range of emergent user communities. In the process, it is also possible that novel designs created by emergent users may be pivoted to the rest of the world, disrupting existing technology mindsets by diversifying innovation in contexts outside of its traditional locations.

In the pages that follow we draw together lessons learned from this undertaking to develop a design methodology—itinerative design—that ties together craft and critique to develop alternative forms of technological future-making. Like iterative design, our approach uses conventional cycles of creating, prototyping, testing, and refinement. Distinct to our method, however, is the process of a single interaction team moving from community to community, to be shaped and challenged by broad and diverse inspirations and ideas, combining these with those of local experts, researchers, and cultural commentators in each place. These ideas and discussions are then analyzed, prototyped, refined, and tested in each of several different driver communities along design's current periphery, allowing us to build up a richer, more appropriate design space for emergent user contexts.

2 RELATED WORK

We are not the first to problematize the discourses that position Silicon Valley as the center of high-tech innovation, and the practices that reproduce its central position [15, 49]. We believe, however, that this narrative's continued preeminence demands continued investigation. In this context, the mobile phone and the innovation practices that surround it—the focus of our research—is a problematic object of particular interest. This is a topic that Toyama [51] explores in his reflections on the HCI for Development (HCI4D) research field. In his view, the mobile phone highlights a great truth that is difficult to reconcile precisely because its opposite is also true: that (1) *"human culture is unique everywhere"* and that (2) *"as human beings we are all the same"* [51, 64]. Speaking of the mobile phone, Toyama notes, *"here's a device that is without doubt the single most popular consumer technology in history, but its UIs have been dictated by developed-world engineers, many of whom probably never engaged with so much as a focus group"* [51, 64]. Clearly this tension between local and global, between cultural specificity and human universality is important when we speak of the mobile phone and the innovation practices that surround it.

The term we adopted earlier—emergent user—exemplifies this. On one hand the term draws attention to the fact that communities across the world—representing hundreds of millions of people—are just beginning to get their hands on modern (albeit often lower-end and lower-cost) mobile technology [12]. But it also flies in the face of qualitative scholarship on cultural specificity. Is it a useful term that binds people together based on common concerns and opportunities—access to modern mobile technologies—or a brash categorization, paying little regard to cultural diversity nor attention to national boundaries? Vashistha et al. [53] explore a similar dynamic comparing hyperlocal educational video content developed by NGOs to those produced by UNICEF that target a much wider audience. Participants in their study largely preferred the latter.

We ally ourselves to scholarship in the HCI4D canon more generally, which focuses on *"understanding and designing technologies for under-served, under-resourced, and under-represented populations around the world"* [11, 2220]. Interventionalist scholarship in the canon tends to focus on what Marsden calls pragmatic designs—*"solutions that do not require adding more technology or infrastructure to a situation"* [23, 43], leveraging more from existing technology. Researchers in this area pay close attention to the issues and challenges faced by the communities they are working in. For example, in many emergent user communities it is common for technical challenges to occur [42]. These challenges can include infrastructure shortcomings or failures (such as power or network outages) but also socioeconomic issues (e.g., lack of funds for airtime, or shared devices [43]). Other issues include a lack of relevant or appropriate information, lower literacy, lower-income, lower technology exposure, and potentially unreliable devices [10].

To overcome many of the challenges faced by emergent users, various designs have been created to make use of lower-end "basic" phones (e.g., [32, 40]) or "featurephones"—precursors to smartphones that typically have low-end network capabilities, basic cameras and simple web browsers (e.g., [16, 25, 30]). Other improvised solutions aim to reduce the cost of airtime or phone calls (e.g., [13]) or dependence on network infrastructures (e.g., [1, 35]). There are also services that address the issues surrounding technological exposure [26], cultural and contextual differences [24], and barriers caused by literacy or language [3, 27, 28, 46].

If such designs are forged from the perspective of a traditional user, however, their value, and indeed their limitations, must be understood and carefully adjusted before making the transition to emergent user contexts [4]. Indeed, it would be naïve to believe that we could simply design a product or service based on traditional users' perception of "easy to use," and expect it to be fit for purpose for entirely different users living in such vastly different contexts [24, 56]. For example, hierarchical menus—commonly used in traditional desktop and mobile platforms—have proved to be extremely problematic for some users [54]. It has also been widely documented that address book functionality is not understood by many lower-literate emergent users [10, 27]. We contribute to HCI4D by working alongside similar user groups, but shift its empirical focus away from leveraging existing mobile technologies to the design of far-off future mobile technologies and interactions.

Methodologically, research in the HCI4D canon tends to focus on the local side of Toyama's spectrum (cf. [51]). Our work is related to and inspired by research that situates design outside of its traditional centers, but again differs from it through our multi-sited approach that upholds Toyama's tensions. Wyche, for example, proposes *"an alternative approach to design, which accounts for the realities of living in a slum,"* in her work exploring mobile phone and social media use in Viwandani, Nairobi [57, 530]. Bidwell's deep reflexive analysis of designing social media in rural South Africa *"challenges many orthodoxies in the centres of design"* in general, and in the HCI4D canon specifically [8, 75]. In Bidwell's view, *"we can enrich design by moving the centre"* [8, 51], but such shifts require deep reflexive engagement with the oral practices of the rural communities she studies and the ontology of personhood-acquired-in-community-relations such practices articulate [8, 63].

Such perspectives overlap with trans-national HCI scholarship that studies innovation sites and cultures beyond California. Drawing on Taylor's influential work [50] and kindred calls for more reflective HCI practice, Avle and Lindtner [6] study sites of technological innovation in Accra, Ghana and Shenzhen, China to tease out from their diversity some more general lessons. They found that *"technology designers and producers in Accra and Shenzhen simultaneously critiqued and located their work in the same center-periphery discourse that [. . .] prior works take on."* The prior works that Avle and Lindtner speak of here are those of critical commentators on technology innovation such as Dourish and Mainwaring and Suchman we reported earlier (cf. [15, 49]). However, this stance differs from Dourish and Mainwaring's strategy to *"avoid the rhetoric of centre and periphery"* [15, 139] altogether, and again brings up the tensions between the local and the global, the situated and the universal. Both Avle and Lindtner [6] and Suchman [49] find nuance in Tsing's [52] characterization that universals only ever exist as locally enacted effects. Tsing's argument draws on post-colonial sensitivities that Irani et al. [19] and Merritt and Bardzell [29] have brought to the attention of mainstream HCI. Suchman relates such effects to future-making practices more specifically, and argues that futures are enacted in what Tsing calls *"the sticky materiality of practical encounters"* [52, 1]. We further ally ourselves with projects that create such encounters through multi-sited design, such as those reported by Williams et al. [55], but again extend their focus to include the design, testing, and shaping of far-future technologies.

Such encounters often occur through an HCI universal that has been *"applicable in every geography and every culture where HCI practitioners have worked"* [51, 64]. Toyama is of course referencing the many variations of HCI's canonical iterative methodology: the observe-prototype-evaluate-iterate cycle. We contend, however, that this cyclical metaphor upholds, rather than enables engagement with, the many tensions prior work identifies. Here, then, we propose, report, and reflect on a variation of HCI's core methodology that extends and contextualizes its cyclical character across and along different places: a methodology that *itinerates* rather than *iterates*.

2.1 Delineating Similarity and Difference

The terms *itinerative* and *iterative* differ by only three characters. In choosing such similar terms, we are inspired by Balsamo's observation that "innovation"—in this case the itinerative design methodology—"cannot be so novel that it makes no sense at all" [7, 10]. While this may seem obvious, the deeper point is that *"to be comprehended, an innovation must draw on understandings that are already in circulation within the particular technocultures of users, consumers, and participants;*

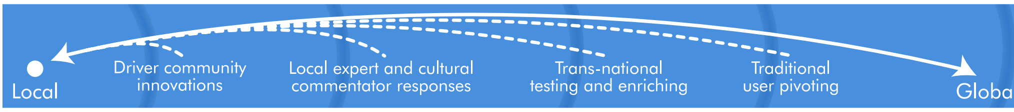

Fig. 1. The itinerative design flow of information—local innovation rippling across regions, circling between stakeholders to inform designs.

at the same time it must perform novelty through the creation of new possibilities, expressed in the language, desires, dreams, and phantasms of needs" [7, 10]. In describing how we practiced itinerative design throughout the pages that follow, the astute reader will find aspects that they are already familiar with: design workshops [21], scenarios [9], or prototypes [44], for instance. In this way itinerative design draws on and integrates HCI methods. But itinerative design also expresses new possibilities. Or, rather, it orients us toward the global dynamics of technological imagination and innovation and the particular places in which these activities typically take place. Thus itinerative design solutions—those that from the *outset* integrate and recognize the particular places in which design activities are situated and that involve diverse communities in the imagination, creation, appropriation, and evaluation of technologies of the future—produce designs that, we argue, are not only innovative but also widely applicable.

The features, then, of the approach that are unique and different to conventional iterative design are as follows: the long-term arc of the iterations; the large distances between the geographical locations in the multi-sited, trans-national framing of the work; the integration of multiple actors (emergent users, local experts, researchers, cultural commentators and developers); and, the closing of the loop with emergent users, so that their initial future-making ideas are brought back in prototype and deployed system forms.

3 ITINERATIVE DESIGN METHODOLOGY

Figure 1 shows the broad vision of the itinerative design methodology. The process begins locally by positioning driver emergent community members not as users [15] or appropriators [48], but as technological innovators and future-makers—terms that we carry forward through the rest of the article. These local driver community innovations are then rippled out and reflected back, first to local experts, and other stakeholders, and then further to emergent and additional user groups in other regions, taking the ideas and suggestions made by initial innovators to other future-makers for further testing, situating, and enriching.

Each cycle—or segment—of itinerative design, then, begins when the core interaction team visits a driver region community of emergent users to conduct intensive innovation workshops with future-makers, which aim to identify a series of interaction challenges and potential technology interventions. Rapid, in-situ ideation, scenario generation, and low-fidelity prototyping are documented before feeding back to local technology experts, NGOs, cultural commentators, and other stakeholders for response and refinement.

Next in the process is the creation of a series of prototypes of techniques and devices to address the opportunities identified during the initial future-making workshops. These prototypes are iteratively developed and piloted in controlled studies across several different emergent communities, refining and adapting between each iteration. Longitudinal deployments are then undertaken within multiple driver regions; again, interpreting, refining, adapting, and situating throughout. Finally, at the end of the process, we look to the global by pivoting to explore how the resultant technologies could be beneficial beyond those communities involved in the design process.

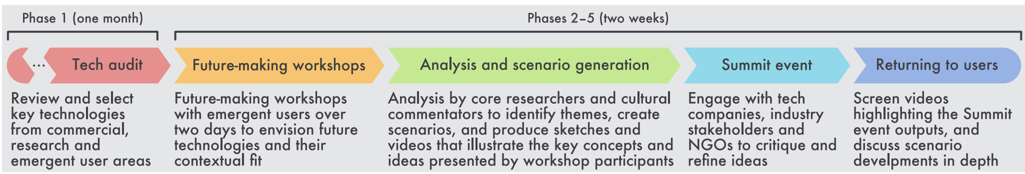

Fig. 2. The innovation sprint portion of the itinerative design process example that we report here was split into five Phases (as detailed in Sections 4.2.1 to 4.2.5), and took place over a focused six-week period. To begin, we conducted a one-month technology audit of existing work to identify key demonstrator technologies. We then undertook a two-week period of intense co-creation with emergent users. The designs and scenarios that resulted are detailed later in this article. We consider ongoing development and deployment of the designs as a separate process, and beyond the scope of this article, though the broad steps followed are shown in Figure 8.

4 ITINERATIVE DESIGN WITH SOUTH AFRICAN DRIVER COMMUNITIES

Here we describe a specific segment of itinerative design that begins by recruiting and engaging future-makers from Langa, Khayelitsha, and Delft—townships located on the outskirts of Cape Town, South Africa. While these zones were established under the apartheid government's Urban Areas Act and designated for Black Africans, they are areas that are in flux. Parts of them remain to this day characterized by informal housing and economies associated with townships, while other areas within them are more formally developed and resemble other suburbs. Across Langa, Khayelitsha, and Delft, we encounter diverse residents. Many speak isiXhosa and have family connections to rural communities in the Eastern Cape, while others have moved inward from townships further afield to live closer to the city center.

4.1 Method

This instantiation of an itinerative design cycle took just over one calendar year in total. It began with a six-week period aimed at tailoring and conducting a series of innovation workshops (see Figure 2), which is the focus of the majority of this paper. We do this to emphasize the importance of exploring methodological tools—such as itinerative design—that can be used by and with future-makers to generate the starting point—the pebbles, as it were—that are key to the rippling out and reflecting back, across design's pool, as the itinerative process unfolds (shown in Figure 1 as driver community innovations). We also report on the ideas and insights co-created with participants during this particular iteration of the process as examples of the richness such future-making activities can afford.

Following this intense ideation process was an 11-month period of development, refinement, and deployments of the ideas generated within these workshops (see Figure 8 for an example timeline), which we report on later in this paper. These stages, shown in Figure 1 as the flows moving from the local, toward the global, and back, carry forward, interpret, situate, and reflect back the innovations generated by driver communities.

4.2 Tailoring Innovation Workshops

Our goal, then, was to work with residents in Langa, Khayelitsha, and Delft to co-create and innovate new forms of technologies and possibilities for the future through a series of innovation workshops. Before we launch into this process, however, it is worth pausing for a moment to reflect on what the meanings of words such as "creativity," "innovation," and "technology" are; or, rather, what claims are being made with these words, and whether these are justified. To *"read* *creativity as innovation,"* in Ingold and Hallam's view, *"is to read it backwards in terms of its results, instead of forwards, in terms of the movements that gave rise to them"* [18, 3].

In such a "backward" reading of innovation, Ingold and Hallam argue, creativity is placed on the side *"of the exceptional individual against the collectivity [...] and of mind or intelligence against inert matter"* (cf. [18, 3]). Here, then, is a first valuable lesson for the itinerate designer. By considering the provenance of pervasive terms, and how these contribute to popular discourses and mythologies of technology, we can integrate important critiques into our methods to, for instance, focus on fostering creative processes starting with smaller ideas rather than innovation outcomes, on relational encounters with others rather than individual brilliance, and on design materials as an active participant in those processes.

Figure 2 shows a basic timeline of the innovation workshops portion of this itinerative design cycle, which comprised of five Phases, each of which drew in emergent users, local experts, and the itinerant team to reflect on a range of potential future technologies. These conversational openers were carefully curated in Phase 1 and ranged from new-to-market commercial products to highly regarded research prototypes. During the remaining four Phases (Phases 2–5), these materials were used to inspire participants, arouse discussion, and generate ideas for future designs that are more suited to the contexts in which emergent users live and work.

The five Phases are as follows:

Phase 1: Preparatory work to select and filter the technology concepts to be used as demonstrators in ideation workshops.

Phase 2: Future-making workshops, which were structured to probe participants' current use of mobile devices, and their daily routines and activities, followed by exercises to evaluate how the technologies we demonstrated might fit.

Phase 3: Analysis of the data, ideas and insights gathered from the future-making workshop sessions, using these to create concept designs and potential scenarios of use.

Phase 4: A summit event with local technology experts, NGOs, and other stakeholders to test and challenge the designs.

Phase 5: A video showcase with the original workshop participants, and others transnationally, presenting the ideas and scenarios generated (in the form of video sketches) in order to evaluate their suitability and use.

The remainder of this article describes this ideation aspect in more detail, before turning to explore the results, insights, scenarios, and trajectories of the ideas generated.

4.2.1 *Phase 1: Preparatory Work—Technology Audit.*

Ingold and Hallam remind us that *"the creativity of our imaginative reflections is inseparable from our performative engagements with the materials that surround us"* (cf. [18, 3]). In our case, the material we are particularly interested in is technology. While the technological landscape in Langa, Khayelitsha, and Delft is rich with creative appropriations of established technologies (such as the mobile phone), there are fewer exemplars to-hand in these contexts of cutting-edge technology developments, both commercial or as research prototypes. Such exemplars, we posit, would form an important basis of discussion. The core team therefore conducted a technology audit in which we selected the following three categories of technology to be demonstrated to and discussed with future-makers: commercial products, state-of-the-art research projects, and emergent user research, borne out of our own previous work with emergent users.

In each category, we selected four representative technologies as follows:

Commercial products: We surveyed popular, "in vogue" technologies from news articles, press releases, videos, adverts, and social media, and selected future-focused, but commercially available technologies. These were as follows: smartwatches; virtual reality headsets; internet-of-things (IoT) beacons; and, quantified self-trackers.

State-of-the-art research: We retrieved the top 20 most-cited and all of the award-winning papers from each of the past 5 years of Google Scholar's top-ranked HCI conferences (CHI, UbiComp, UIST, CSCW, INTERACT, DIS, MobileHCI) and journals (IJHCS, TOCHI), filtering to select those that were mobile, or related to mobile devices, giving a total of 74 publications. Four of the core research team then individually rated the systems in each paper in terms of how valuable they would be during the future-making workshops (in terms of relevance, connection to emergent user contexts and ability to demonstrate the technology in situ). We then categorized the top-rated papers, giving four overall themes as follows: interaction through phone gestures; interaction through on-body touches; interaction through object manipulations; and, interactions with multi-screen devices.

Emergent user research: The itinerative design process is an annual cycle, of which the example given here was the second year. In this category, we included four technologies designed and prototyped by future-makers in previous years. These were as follows: a multi-device tool to split components of complex services across a group of phones; a phone that is able to camouflage itself; a deformable mobile device; and, a speech recognition service. Introducing these technologies during design workshops illustrates one aspect of what we mean by transnational testing and enriching (see Figure 1). Engaging with previous work also showcases how previous prototypes or design experiences are better figured as continuations in itineration rather than new beginnings in iteration.

4.2.2 Phase 2: Future-Making Workshops. The aim of the workshops was to get future-makers to think about how the example technologies we demonstrated could fit into their lives, using these as a catalyst to imagine potential devices and interactions that could later be prototyped and refined. We invited 24 future-makers to take part in a full-day workshop held in Langa's library. Participants were recruited by a Langa-resident facilitator who we have had a long working relationship with, and places were advertised via local networks. We repeated the workshop over 2 days, with 12 people taking part each day. In the first workshop (8F, 4M), all participants owned smartphones except for one participant who owned a basic phone. In the second workshop (9F, 3M), seven participants owned smartphones, and the remainder owned featurephones. Participants were aged 18–45 years, English speaking, and had a mix of technology experience and literacy levels, but all lived in lower social-economic areas. There were a range of backgrounds and occupations, but participants were primarily students, casual laborers, or unemployed. All participants were compensated for their time.

After welcoming participants over breakfast and explaining the project outline and goals, we undertook an IRB-approved informed consent process, then moved on to scene-setting activities, followed by a dive into the potential future technologies selected during Phase 1.

Setting the scene: As an icebreaker exercise, and to help participants reflect on the activities, places and technologies involved in their daily lives, we handed out workbooks to be completed over the course of the day. The start of these booklets collected basic demographic and technology-usage or ownership information, after which followed a group-based discussion probing device desires by asking what participants would *like* to be able to do with their devices in the future.

Next, each participant sketched out a typical weekday in their lives, illustrating the activities they would normally be doing over the course of a day (see Figure 3 (left)). This was followed by sketches of three distinct locations that they visited often. Finally, participants annotated their sketches to show how often they currently used their mobile phone at each time or place (from "all the time" to "never"). Local videographers filmed and documented personal accounts of both

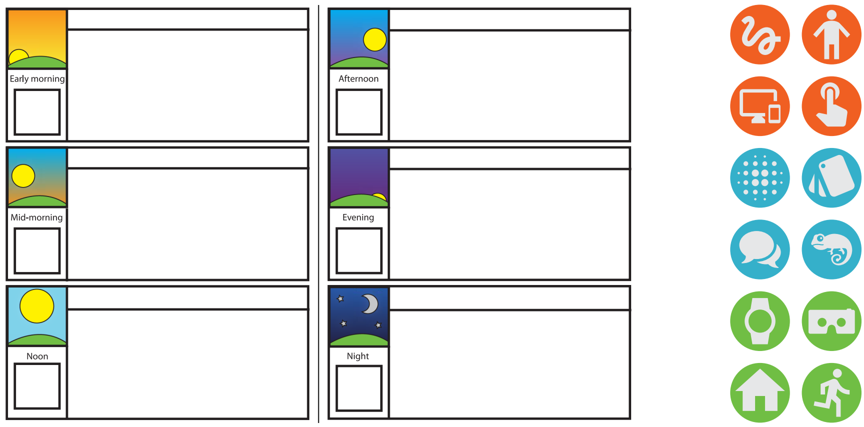

Fig. 3. Left: sample pages from the workbooks in which participants sketched and narrated their weekday activities, split into six time segments from morning to night. Right: the 12 stickers used in the emergent users workshops. Top (orange, row-by-row): phone gestures, on-body touches, multi-screen devices, object manipulations. Center (blue): deformable devices, mobile disaggregation, speech recognition, camouflaging devices. Bottom (green): smartwatches, virtual reality, IoT beacons, quantified self.

the participants and researchers during each workshop. Beyond simply documentation, we chose to engage with videographers to further inform and shape the design process. In this sense, as Gaver [17] argues, videographers can be seen as a type of *cultural commentators*—professionals who *"work outside our usual community of discourse, and are often accustomed to reflecting issues of aesthetics, emotions, social fit or cultural implication that are difficult to address from traditional HCI perspectives"* [17, 292]. In our case, videographers compiled, framed, and interpreted the footage and impressions they gathered during the workshop into a short film about the process and results to be presented to attendees at the summit event (Phase 4), and to the future-makers at the video showcase (Phase 5). We hoped that such polyphonic assessment [17] and interpretation [45] would enrich the process and help to recover and express the knowledge surrounding design spaces that can be difficult to articulate through text, but that unfolds along the generative process of design [47]. Creating opportunities for such interpretation and integrating response is central to the itinerative design methodology (see Figure 1).

Thinking about the future technologies: The remainder of each workshop day was spent walking through and discussing with participants the technologies identified in Phase 1. Each technology category was demonstrated in a different part of the room, and participants moved in groups of four people between each area, spending about an hour discussing each theme. For each theme, the process began with demonstrations by the researchers of each technology, followed by a group-based feedback session around the potential suitability, usage, and any immediate advantages or disadvantages that they foresaw. We also wanted to determine when, where, and during what activities the future-makers felt each technology would be most beneficial to them. To do this, we referred back to the sketches created in the set-up activity, and provided participants with colored icon stickers for each technology (see Figure 3 (right)). For each separate technology, participants were given one sticker to place at a time of day, and one to place in a location that they thought this technology would work best.

Toward the end of the workshop, we asked participants to rank each technology in order of how useful it might be to them, then summarized the day, reiterating how the results would be used, and that the video showcase the following week would give an opportunity to critique the ideas generated.

4.2.3 Phase 3: Analysis and Scenario Generation. Following the future-making workshops, four members of the research team undertook an intense period of in-situ data analysis (including all participant workbooks and feedback notes), to identify themes, issues, and potential avenues for exploration and prototyping. As part of this investigation, we extracted and clustered the technologies participants saw as most useful into themes, and determined the most popular times, activities, and locations in which they could be used. These analysis sessions involved a series of iterations of design concepts that encapsulated as much of the workshop data as possible.

This process ultimately led to four separate design concepts. At this stage, we recorded verbal narratives of how, why, where, and when each design might be used, and sent these to a remote sketch artist who created a draft storyboard for each idea. These storyboards were then used to create short (2 to 4min) videos highlighting the purpose and interaction of each scenario. Each video consisted of a series of hand-drawn sketches enhanced with an audio script of the scenario of use. These basic videos were designed to be as simple as possible to understand, and focused entirely on the user interaction and functionality of each idea, rather than the technical requirements or inner workings. These scenarios, in both sketch and video form, were used in illustrating the ideas to local stakeholders (during the summit event, Phase 4) and, after further refinement, to return to future-makers for feedback (during the video showcase, Phase 5).

4.2.4 Phase 4: Summit Event. The insights and ideas created by participants in the future-making workshops were used as input to a summit event to which a range of local stakeholders were invited, including an interdisciplinary mix of industry, NGO and academic researchers, developers and designers, all of whom had experience of working with and for emergent users. The broad aim of the event was to gather additional perspectives on the technologies explored during the earlier future-making workshops.

The event began with a set of "moonshot" pitches, in which attendees were invited to give suggestions or comments about their own vision of the future of technology in store for emergent users. We then moved on to set the scene by describing the method, results, and outputs of a previous itinerative design cycle, and screened the film created by the videographers during the future-making workshops. A group breakout activity followed, exploring the same three technology themes as in the future-making workshops, mirroring the process undertaken in those events, with time to discuss each technology and its potential applications in depth. Participants were then asked to choose the technology category that they felt most passionate about, and work together in groups to generate basic scenarios that best encompassed its potential applications, given their knowledge and experience from working with emergent users. The aim of this activity was to encourage ideation using these future technologies in transformative ways. The activities concluded with reports and idea walkthroughs from each group, which were captured on video to be shown to the future-makers during the video showcase (Phase 5). Finally, we screened the early concept videos and sketches generated as outputs from the future-making workshops in order to gather feedback, which was then used to further refine and extend the existing scenarios in preparation for the next Phase.

4.2.5 Phase 5: Returning to Users—Video Showcase. The final aspect of the intense 2-week ideation process was a video showcase event, presenting all of the ideas generated by the future-makers, research team, and summit attendees back to the original future-making workshop participants. We began the showcase by showing the films made by the videographers during the events, which encapsulated the process and approach of the workshops and summit. Sharing this video with our future-maker partners was essential to ensure that they were happy with the way we conducted, analyzed, and reported on the research. We then screened each of the idea videos from the summit event (Phase 4), and the scenario videos that had been generated over the whole process. After each video, participants spent time discussing the idea to probe its suitability, uncover potential issues, and then rate (Likert-like scale: 1–7; 7 high) and rank each scenario in terms of how useful it would be for themselves and their friends or family.

4.3 Prototyping, Refining, Deploying, and Evaluating

After completing the innovation sprint, we undertook an 11-month cycle of development, refinement, deployment, and evaluation, consisting of five additional Phases. Each idea generated through the innovation workshops has been developed through its own cycle of the following aspects:

Phase 6: Creating a basic working prototype of the design to demonstrate to participants in each driver region (both that generating the idea, and other regions worldwide).

Phase 7: Lab studies in each driver region. Between each lab study in each location, prototypes are refined based on ideas and feedback from participants, before looping back into driver communities for enrichment and enhancement.

Phase 8: Intense development work, creating a robust, deployable version of the prototype system.

Phase 9: Longitudinal deployments with emergent user communities in driver regions, involving both original participants from the future-making workshops and additionally recruited testers. Similar to Phase 7, prototypes are refined, enhanced, and enriched between each iteration.

Phase 10: Pivoting back and expanding to wider communities. Typically, this stage involves the release of an open-source toolkit, and a launch event to drive wider adoption and use.

A detailed study of Phases 6–10 of the itinerative design process in detail is beyond the scope of this article, but an example of a completed cycle with one design scenario that resulted from the work reported here is illustrated in Figure 8.

5 KEY INSIGHTS

As might be imagined, a full cycle of the itinerative design method generates a vast amount of data and ideas. The focus of this article is primarily around the method, rather than the results of a specific iteration, so, we report here only on the key scenarios and insights gathered from the single itinerative design segment detailed in the previous section.

During and after analyzing the workbooks, design critiques, scenarios and feedback produced during Phases 1–5, a range of overarching designs emerged. The future-making workshops (Phase 2) revealed clear challenges, and preferences for certain technology types over others. The data analysis and summit event in Phases 3 and 4 led to a set of four clear scenarios that we also present here. Finally, the video showcase (Phase 5) offered an evaluative critique from the future-makers who had originally provided the stimulus for these scenarios.

5.1 Design Challenges

Six core design challenges were identified after the future-making workshops. While many of these concerns might not come as a surprise to those working regularly with emergent users, their recurrence highlights how current ways of designing technology are not working for these communities.

Security: The most commonly highlighted design challenge was the topic of security, both in terms of personal safety (i.e., mugging) or that of possessions (i.e., burglary). As previous work has revealed (e.g., [31]), emergent users are often especially wary about being seen

Table 1. Technologies Demonstrated in the Future-Making Workshops of Phase 2, Ranked in Order of Preference (1: highest; 4: lowest)

	Commercial products	State-of-the-art research	Emergent user research
1	Smartwatches	On-body touches	Speech recognition
2	Virtual reality headsets	Multi-screen devices	Service disaggregation
3	Quantified self-trackers	Object manipulations	Deformable mobiles
4	IoT beacons	Phone gestures	Camouflaging

to use or own valuable technologies, so ways of discreetly carrying or using these devices are highly desirable.

Money: Participants were adept at discovering ways to generate or save money, whether by publicizing locations that provided free internet access, or sharing knowledge about discounts and special offers in local shops.

Connectivity: Keeping in touch is an essential activity in Langa, just as it is elsewhere. However, using mobiles to achieve this is a tradeoff: data packages can be difficult to afford, and costs without an internet-backed service (e.g., WhatsApp) are far higher (e.g., SMS; phone calls).

Education: Female participants in particular stressed the need for education, both for themselves and for their children. Finance issues arose again in relation to this challenge, including those around data connections and technology availability for children to complete homework.

Sharing: Participants spoke about how they would often borrow or lend phones between friends, both if consumables (such as battery, airtime or data) were low, but also if the borrowed device had better features, such as a higher resolution camera or a larger screen. This was often related back to topics such as homework, particularly on small screens.

Privacy: Many participants spoke of sharing a single device with other members in their family (often younger siblings or older parents), but voiced concerns over the privacy of their data and communications when doing so.

5.2 Technology Preferences

Turning now to the three technology categories participants experienced and interacted with in the future-making workshops. We asked participants to rank each category's technologies in order of potential usefulness. Aggregating these scores gives the listing shown in Table 1, given in order of most (ranked 1) to least preferred (ranked 4).

There was a strong preference for technologies that allowed for discreet or hands-free interaction, as demonstrated by the most favored items in each category. The majority of the participants who selected a smartwatch as the most useful device in the commercial technology category reported that they did so because they believed it would be safer than carrying a mobile phone. That is, any potential thieves would not necessarily be aware that the smartwatch was a valuable object, which would make them less likely to be targeted for robbery. This theme of security also resonated in the preference for speech recognition, with many participants stating how useful it would be to be able to discreetly send or receive messages without needing to show their phone in public.

Beyond the highest-rated technology in each category, there was a high amount of variability in the choices made. The future-maker participants were particularly excited about virtual reality for learning, and deformable or camouflaging mobiles, but saw these as further off in the future, and so less immediately relevant. There was more excitement about the quantified self-trackers,

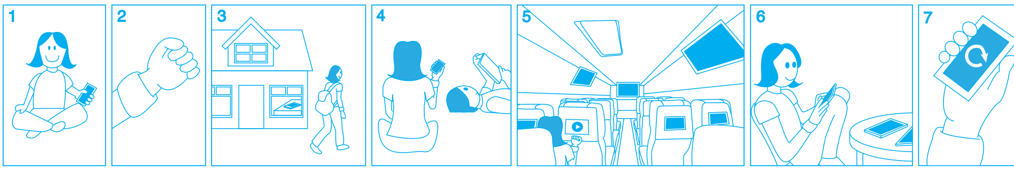

Fig. 4. Safety Pod. (1) Rini is worried about carrying her phone with her when she goes out, as she is worried that it might be stolen. At the same time, though, she likes being able to access her information, make calls or take photographs. (2) So, she invests in a Safety Pod: a small, cheap device that she can wear discreetly on her wrist. (3) Rini leaves for school, wearing the Pod, but leaving her phone behind. (4) On the way, she stops at her friend Lucy's house. After getting permission, Rini picks up Lucy's phone and, upon entering her password, it automatically synchronizes with her Pod, transferring all her vital information to the borrowed phone. Lucy's phone is now acting as Rini's own device, and she is able to view or add to her media, access her messages and call her contacts. During her time there, Rini uses Lucy's phone to take a selfie of the two of them together. Before leaving, Rini logs out of the borrowed phone, which updates any changes back to her Pod (including her selfie), and deletes any remnants of information left on Lucy's phone. (5) On the minibus taxi on the way to school, Rini logs into an entertainment system and uses it to watch the videos stored on her Pod. (6) Arriving at school, Rini heads to the library and picks up a communal tablet. Once her password is entered, the tablet becomes hers for the duration of her time with it, and she is able to catch up on emails about homework from her teacher. (7) When back at home, Rini picks up her own phone and synchronizes it to her Safety Pod. All of the updated data from the devices she used throughout the day has now been transferred back to her own phone.

and the IoT beacons, which participants saw as a way to remain connected to others and their surroundings at low-to-no cost (due to the use of Bluetooth). Finally, the themes identified from the research literature were on the whole less attractive to participants. Perhaps in a reflection of the existing flows of technology we have discussed earlier in this paper, participants saw little relevance in these devices to their own everyday lives.

5.3 Themes and Scenarios

After the analysis, there were four distinct ideas for technologies as guided by the future-maker workshops. As described earlier, these were initially sketched as storyboards, and subsequently made into illustrated animations for use in the video showcase event (Phase 5). Figures 4, 5(a), 5(b), and 6 show extracts from the illustrations and voiceover text for each of the videos created. The following sections describe each of the scenarios in brief, and highlight the key insights from future-maker participants that shaped their design.

5.3.1 Safety Pod. The Safety Pod scenario (Figure 4) was directly influenced by several future-makers' comments regarding the smartwatch technology demonstration. The aim of the scenario was to separate the interface of a phone from its hardware, allowing users to share and co-opt other devices at will. As was highlighted in both the design challenges and technology preferences that participants discussed, personal and physical security aspects currently dominate their lives. The fact that the scenario involved a device that was *"just a watch"* and would therefore be less of a potential target for robbers was critical. Other benefits of the approach, which overlap with the themes described above, are the ability to share resources (e.g., using someone else's phone to take a photograph, and saving this to a Safety Pod, as described in Figure 4). Privacy is also protected in this scenario, as any content created or used on borrowed devices gets deleted after use, which makes the design useful for those who share phones.

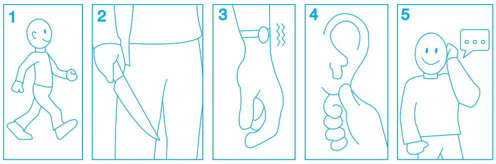

Fig. 5. (a) Audioliser. (1) Tosin is walking down the street in a dangerous part of town. (2) He does not want to take his phone out of his pocket, as he is worried about drawing attention to himself. (3) Instead, he is carrying an Audioliser—a small, button-sized module that can be hidden in his clothing; perhaps in the sleeve of his jacket, or within a bracelet on his wrist. When he receives a new WhatsApp message, the Audioliser vibrates gently to alert him. (4) Feeling the vibration, Tosin can discreetly bring his arm to his face and make a natural gesture, such as tugging his ear. (5) This action triggers the Audioliser to quietly read out the message for him to hear.

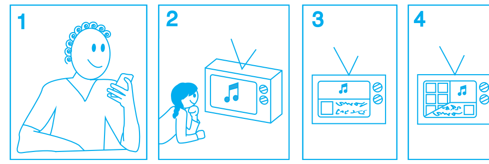

Fig. 5. (b) Screen Splitter. (1) Ziggy is using his phone to research a school project. He finds its screen very small for this sort of task, however, as there is a lot of text, and many pictures to display at once. (2) So, he moves to the living room where his sister, Wani, is watching videos on the family TV. (3) Ziggy points his phone at the TV, and it splits the screen in half, showing his research on one section, and Wani's videos on the other. The siblings each continue with their activities, sharing the screen. (4) Later, their mother arrives, and points her phone at the TV too—the screen splits again to give space to view her photos at the same time as Ziggy's work and Wani's videos.

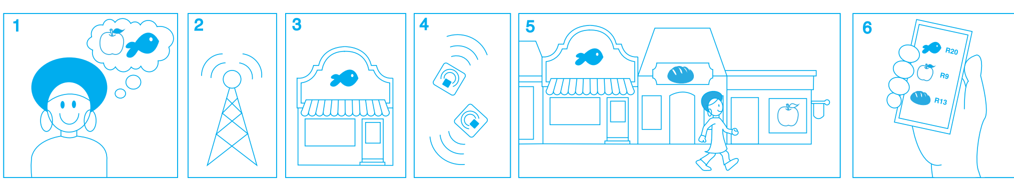

Fig. 6. (1) Lele is going shopping, and is looking for good deals on fruit and fish. She currently has no airtime on her phone, though, so cannot look-up any potential offers beforehand. (2) Luckily, the town where she lives has installed a new Bluetooth shopping beacon system, allowing local businesses to broadcast their special offers for potential customers to see as they walk close by. (3) Today, for instance, Dick the fishmonger has specials on cob and hake. (4) Dick uses his phone to program his beacons with the special offers, and places them in his shop. (5) As she walks down the busy shopping street, Lele pulls out her phone to request from the beacons a list of special offers available in the stores nearby. (6) Being in range of a number of shops, her phone shows a list of her favorite items, and the special offers that near to where she is located.

5.3.2 Audioliser. The Audioliser scenario (Figure 5(a)) was also inspired by the overwhelming issue of safety and security amongst future-maker attendees. Many participants, having had devices stolen in the past, would not even consider using them in public, with most choosing to simply leave their phones at home when going out. It was also evident, however, that keeping in touch with friends and family was a big part of participants' daily lives, showing a clear disjoint between the desired and actual use of their devices. During the workshops, then, participants spoke of a device that could be hidden, perhaps in clothing, and that could use a combination of subtle gestures and speech recognition (as also highlighted in the technology preferences) to both quietly read out messages and discreetly reply without ever having to reveal that a phone was present.

5.3.3 Screen Splitter. The Screen Splitter scenario (Figure 5(b)) arose after it became apparent that screen real-estate was a major issue for many future-maker participants. Only having access to a single device, as many future-makers did, means that this single device—more often than not, a phone—is the only way of interacting with the digital world. This sole-device ecosystem means that screen size is critical, particularly when that device is used for studying, as it was by many participants and their children. Typically, however, participants did have television sets in their homes. The concept of splitting a single larger screen to give multiple users access to more space was suggested during the demonstration of the mobile disaggregation service as part of the emergent user research theme.

5.3.4 Shopping Beacons. The Shopping Beacons scenario (Figure 6) was inspired by participants' desires to find and share ways to save money. One common money-saving technique, often recounted by participants, was to utilize and share shop "specials," which give reduced prices on certain goods. Although deals were common, participants complained that it was difficult to find which shops offered such discounts, even when in the vicinity of multiple retailers, as this required them to visit all of the stores and compare prices. The IoT beacons, then, offered a cost-free way to broadcast offers beyond the physical boundary of the shop, helping the consumer to save money, and allowing the shopkeeper to promote their business more widely.

5.4 Video Showcase

A week after the emergent user workshops, we ran two concurrent video showcases (Phase 5). One of these events was held with the original future-making workshop participants from Langa, Khayelitsha, and Delft, and another was with a group of emergent users from Nairobi, as part of the process of returning and reflecting to others transnationally that we describe in Section 3.

In Cape Town, 19 of the original 24 participants attended the video showcase. There was a great deal of discussion around each of the ideas, leading, ultimately, to the Safety Pod scenario being chosen as the most preferred. In total, 78% of participants chose this as their favorite design idea, and the scenario also received the highest overall rating of 6.9 in terms of usefulness (Likert-like scale: 1–7; 7 high).

The second most highly rated scenario was the Audioliser design, with an overall rating of 6.3, and the remaining 22% of participants picking it as their first choice. The least liked idea from the Cape Town group was the Screen Splitter, with an average rating of 5.2, and 56% of participants choosing it as their least favorite choice. The Shopping Beacon scenario received mixed results, with the majority of participants choosing it as their second or third choice, and scoring it 5.3 out of 7 on average.

We recruited 12 future-makers (7F, 5M) to take part in the video showcase in Nairobi. Participants were aged 18–35, and were from backgrounds broadly similar to those of the future-makers who participated in Cape Town. All except one participant owned a smartphone, and again there were a range of occupations (e.g., student, marketer, event supporter), with two participants unemployed. In this setting, the Shopping Beacon scenario was the most highly rated (6.5 out of 7 on average), with 33% of participants choosing it as their first choice. Half of participants selected the Safety Pod scenario as their favorite design, despite giving it a slightly lower average rating of 5.9. As in the Cape Town showcase, the Screen Splitter scenario was seen as the least suitable, with an overall score of 3 out of 7, and 75% selecting it as their last choice.

The overall results for participants' favorite and least favorite scenarios are shown in Figure 7. There is a preference for the Safety Pod scenario in both locations (although particularly in Cape Town), with 68% of all participants choosing it as their first choice. Qualitative results strongly support this choice. One Nairobi participant, for example, commented: *"[the Safety Pod] is a mind blowing device that would almost eliminate the hassle of carrying a phone and would definitely increase productivity."* Conversely, the Screen Splitter scenario was clearly the least liked, with 65% of all participants selecting it as their last choice.

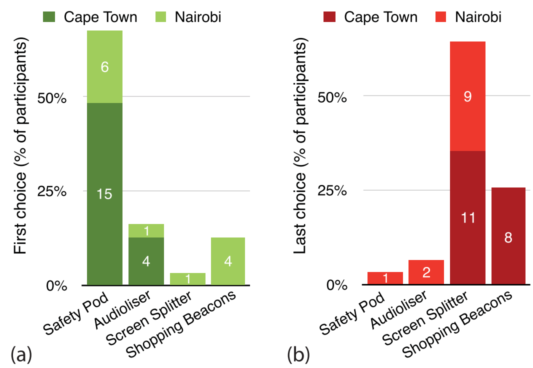

Fig. 7. Combined results from the video showcases in Cape Town (with 19 of the original 24 participants) and in Nairobi (12 participants). Graphs show stacked results: (a) the percentage of participants who chose each scenario as their *favorite*; (b) the percentage of participants choosing each scenario as their *least favorite*. Bar labels are the numbers of participants choosing each scenario in each case.

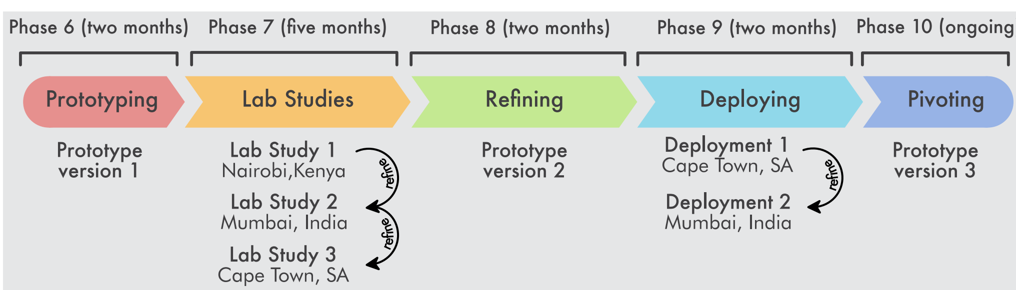

Fig. 8. An example of the subsequent development, refinement, deployment, and evaluation stages of the itinerative design process, in this case showing the steps undertaken with the Safety Pod scenario. At each stage, designs, prototypes, and results are reflected back, including, wherever possible, to those future-makers who originally helped generate the ideas, and then used to inform subsequent steps.

6 COMPLETING THE CYCLE

As Figure 2 illustrates, the five Phases of the itinerative design process that we focus on in this paper (i.e., Phases 1–5), span a relatively short time span when compared to the remaining aspects of the process (shown in brief in Figure 8), which took approximately one calendar year. Immediately following the period of ideation and scenario generation that we describe above is an intense journey of prototyping and evaluation that involves significant engagement with multiple driver communities. The goal of pivoting ideas between these different sets of geographical future-makers is to refine and enrich the ideas generated to create truly diverse and applicable interaction and transaction techniques for these communities. To illustrate the next steps taken in the itinerative design process, we describe as an exemplar the subsequent stages we undertook with the most popular generated scenario: the Safety Pod design. It should be noted that the other scenarios also stimulated prototypes and deployments (not reported here) with evidence of their value to users and communities. For example, the Audioliser led us to consider the use of speech systems in public settings [33, 36]; and, a Google Physical Web trial emerged from the Shopping Beacon scenario [34].

Figure 8 shows the further stages in the continued development, evaluation, refinement, and deployment of the Safety Pod scenario. As can be seen in the illustration, each stage of the process is highly focused on emergent user involvement. We began by building a high-fidelity prototype of the Safety Pod, using the comments and suggestions received from stakeholders at the summit event (Phase 4) and the feedback from future-makers (Phase 5) as a starting point in its refinement. Throughout the course of the following year, the core project team then travelled to three distinct emergent user communities across three driver regions to perform lab-based evaluations of an initial probe, adapting and refining the prototype between locations. After feedback from trials in Kenya, South Africa and India, we constructed a deployable version of the prototype, compatible with the mobile devices emergent users currently use. This version was taken on by community members in Cape Town and Mumbai for long-term deployments on their own phones. Finally, after the deployment, we undertook a further cycle of refinement, and have released the refined design—APPropriate—as part of an open-source toolkit [39].

In other cycles of the intinerative design process, the work has also led to a phone connectivity toolkit[1] being integrated into an Indic language keyboard application that is actively used by 800,000 people; and, to a series of high-profile research articles (e.g., [20, 31, 33, 37, 38]). Such outcomes suggest to us that the process and the perspectives it brings can and do generate ideas that are novel, fresh, and useful.

7 DISCUSSION AND CONCLUSIONS

The aim of the itinerative design process is to think disruptively and imaginatively about future devices from the perspective of emergent users. Understandably, a good proportion of the work in HCI4D and ICTD areas to date has focused on the technologically lowest common denominators to reach as many people as possible—for example, by adapting traditional interactions and services for lower-end devices. Meanwhile, most commercial innovations and cutting-edge research endeavors focus entirely on the mainstream "first-world" population, typically being designed to fit a future, in terms of resource availability, cultural practice and context, that is out of joint with that lying ahead for emergent users.

So, our challenge in this work is: whose future is it anyway?

We argue that involving emergent users in the creation of far-off future devices—in the same way that mainstream innovators have been involved for some time—not only gives these future-makers the opportunity to forge their own technological destiny, but also leads to unique and innovative ideas and solutions, examples of which we have shown here. While traditional designers are typically constrained by what they know to be "impossible," "infeasible," or "insignificant," the different perspectives presented by emergent users often lead to ingenious and inventive services, interactions, and designs—designs that could benefit other users, worldwide.

This research has shown how itinerative design can be used to stimulate and refine ideas and solutions to the challenges faced by emergent users, allowing them to become co-creators of future technologies both for themselves and for others. Here Tsing reminds us that "the universal offers us the chance to participate in the global stream of humanity" [52, 8]. This chance, as our research demonstrates, can and should be made available to those outside of global centers of innovation. But Tsing also cautions us that the universal does not make everything everywhere the same, either. Instead, we must become embroiled in specific situations. In her view,"*engaged* universals travel across difference and are charged and changed by their travels" [52, 8, emphasis added]. Through the process of *pivoting*, itinerative design foregrounds and achieves precisely this.

We have given an insight to our method, and illustrated its benefits via a discussion of the reactions and generated scenarios from a single cycle of the itinerative design process. The novelty in our approach is twofold. Firstly, we have focused on involving emergent users in the co-creation

[1] https://www.bettertogethertoolkit.org/.

of far-off future devices, rather than adapting currently available technology to better suit their everyday needs. While such work is laudable, we argue that, as we have seen in the challenges presented by future-maker participants, the core focus of design needs to shift to better encompass the actual needs and desires of emergent users. Secondly, we have presented both a method and validation of the need to invert the nexus of design activity, pivoting existing flows to be driven by emergent users, with ideas and insights rippling out and reflecting back between transnational communities. This particular cycle of itinerative design unearthed a trove of insightful ideas, challenges and scenarios which, with the help of our future-maker, project and summit partners, grew and evolved to generate a set of distinct ideas about future technologies for emergent users and beyond.

ACKNOWLEDGMENTS

We would like to thank all of the future-maker participants who attended and contributed to the workshops and summits described in this paper. We also gratefully acknowledge the support of Minah Radebe, Frankline Mogoi, Francis Mwangi, and Shashank Ahire in facilitating workshops and other events as part of this research. Finally, we would like to thank Desmond Bowles and Jamie Dimitra Ashton for their work on videography, and Makayla Lewis for her concept sketches.

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Received June 2018; revised March 2019; accepted May 2019