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Participation in Co-design:

In Search of a Recipe for Improved Cookstoves in Urban Indian Slums

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Key words

Co-design, co-creation, community participation, participatory approach, household / indoor air pollution, improved cookstoves, urban slums, India

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Abstract

This study responds to the need for participatory, context-oriented approaches to address the growing health threat of indoor air pollution faced by marginalised communities of urban India. It explored the application of the co-designing model employed by Project Exhale in two non-notified slums in Bangalore, by analysing processes and tools of multi-stakeholder collaboration, the knowledge that emerged from them, and its translation into the designing of improved cookstoves. Bringing the end-users, designers and researchers onto a common platform led to the generation of contextual, user-knowledge, and technical expertise, which were transferred to the development of the prototype. In this process, stoves' suitability concerns traditionally raised in literature are not seen as barriers to implementation, but issues that can be addressed and negotiated through participatory methods. The involved actors experienced a parting from pre-defined, traditional roles towards more flexible ones, as required by the project at different stages. Tools employed for the knowledge exchanged within this community of practice needed continuous exploration, negotiation and adjusting, as transferring the co-designing model in resource-limited settings demands higher flexibility and a grounding of activities in local experiences.

Key words

Co-design, community participation, participatory approach, household / indoor air pollution, improved cookstoves, Indian urban slums

Introduction

Over the years, low hanging technological fruits (Banerjee & Duflo, 2011), from diagnostic technologies, to bed nets, medicines or contraceptives, held great promise in saving the lives and improving the quality of life of millions across the globe at a minimal cost. Yet, many of these solutions have underachieved, or entirely failed in meeting their targets. One such example is tackling Indoor Air Pollution (IAP) through the use of improved cookstoves (ICS). The chief source of IAP is the incomplete combustion of biomass fuels when cooking on open fires or traditional stoves, which releases dangerous pollutants such as carbon monoxide, particulate matter and volatile organic compounds (Gilman, et al., 2015; Sinha et al., 2006; World Health Organisation [WHO], 2016). Exposure to these substances can lead to non-communicable diseases like stroke, lung cancer, ischaemic heart disease, chronic obstructive pulmonary disease and others (Fullerton, Bruce & Gordon, 2008; WHO, 2016). This makes IAP the largest environmental health risk factor globally, claiming 4.3 million deaths annually, or 7.7% of global mortality (WHO, 2016). Its toll is distributed disproportionately at global level, with approximately 80% of the total global exposure to IAP occurring in low and middle income countries (Fullerton, et al., 2008; WHO, 2016.). In India alone, approximately 700 million people rely on using pollutant fuels on open fires or traditional stoves (WHO, 2014; World Energy Outlook, 2006). While moving up the 'energy ladder' is seen as one of the desirable solutions to these practices (Joon, Chandra & Bhattacharya, 2009; WHO, 2016), the shift to cleaner fuels like liquid petroleum gas or electricity is a challenging course of action that entails considerable changes in systemic, environmental, social or economic circumstances of those affected.

In the field of fighting IAP, ICSs are widely seen as the low hanging technological fruit, as the WHO (2016) recognises that ‘further innovation, research and investment may indeed produce affordable biomass stoves that meet the indoor air quality guidelines’. They can increase fuel combustion, and thus, reduce the release of harmful substances, or can remove these substances from the household living environment through chimneys (Barnes, Kumar & Openshaw, 2012). Their promise holds that they are affordable and do not entail major changes in the lifestyle or environment of users, including the use of similar fuels as on traditional stoves. While the appeal is evident, numerous well intentioned interventions and programs have failed to produce the expected health improvements. A frequent example identified in literature is the Indian National Programme on Improved Chulhas (NPIC). The NPIC distributed in rural areas approximately 34 million ICSs in the 1980s and 1990s, only to be found that a few years after the cessation of the program, virtually none of them were in use anymore (Chengappa, Edwards, Bajpai, Shields & Smith, 2007; Sinha, 2002; WHO, 2016;). Historically, the poor outcomes of such interventions are not limited to technologies in the field of IAP, but have plagued health and development action centred on numerous other technologies (see Frost & Reich, 2009; Leach & Scoones, 2006). Among others, studies have identified issues of long-term access, lack of user friendliness, high maintenance costs, neglect to address contextual user needs, poor communication with end-users and within the implementing stakeholders, lack of perceived benefits for users and differences in use between real-world settings and laboratory testing environments (Barnes et al., 2012; Chengappa et al., 2007; Frost & Reich, 2009; Hanna, Duflo, & Greenstone, 2012; Sinha, 2002; WHO, 2016).

Responding to implementation failures of numerous technologies in resource-limited, marginalized populations, health and development discourse has increasingly stressed that successful innovation and application of technology is conditional upon the specific character of local contexts. As a result, Sesan (2014) argues, participatory models have become progressively more prominent in facilitating the identification and implementation of contextually relevant solutions.

In this article we explore an ongoing intervention in India that aims to develop and implement ICSs in two non-notified (or not recognised by the government) urban slums through participatory methods. So far, IAP and actions to tackle it have been understudied in such settlements, seeing that most attention in the field is drawn by rural areas. However, the urban slums population is projected to increase at a rapid pace in numerous urbanising, developing countries, raising the need to explore context-relevant approaches and solutions to IAP in these settings. In the following section we briefly introduce the background, legacy and principles of participatory approaches to technology design.

Participation

Participatory designing (PD) emerged in the Scandinavian Peninsula in the 1970s (Hussain, Sanders & Steinert, 2012) against the backdrop of a global wave of scrutiny and criticism brought to the dominant, top-down paradigm of development (Huesca, 2002). Initially it responded to needs to democratise workspaces by increasing workers' influence in the workplace, and later, in the American model, it was used as a tool to improve products by drawing upon end users' knowledge (Hussain, et al. 2012; Puri, Byrne, Nhampossa & Ouraishi, 2004). PD challenged the traditional, yet still predominant to this day, role of designers as sole creators in the designing process (Szebeko & Tan, 2010). With the turn of the millennium, participatory models in design experienced a renewed interest among authors, designers, and developers, generating a proliferation of models such as co-designing, co-creation, user-centred design, inclusive design, transformation design and experience-based design (Szebeko & Tan, 2010). These models share the view that end-users should have a voice, or presence in the development of technologies. However, the extent of their involvement can vary, placing them in different categories on participation continuum models which assess the level of end-users' participation (see, among others, Arnstein's Ladder of Citizen Participation in 1969). Moreover, it should be kept in mind that their application in the field and use in literature is not always clearly defined, and different models are often

employed interchangeably (Huesca, 2002; Koskela-Huotari, Friedrich & Isomursu, 2013; Sanders & Stappers, 2008).

For the purpose of this study and the project under consideration, we employed the co-designing model. Co-designing emphasises the right and necessity to involve users at all stages of planning and developing solutions that directly affects their lives. It envisions a shift from ‘designing *for* the people to designing *with* the people’, whereby end-users are seen as collaborators, ‘experts of their experience’, rather than research subjects (Sanders and Stappers, 2008; Szebeko & Tan, 2010). This view of end-users discourages the arbitrary attribution of characteristics to a target population by technology implementers or developers. Instead, it promotes partnerships and knowledge sharing in developing and implementing context-tailored solutions and address issues of acceptability and sustainability. Moreover, by involving all stakeholders in the decision-making process, it aims to ensure transparency and equal representation, and promote shared ownership over the activities’ processes, end-solutions and their delivery (Szebeko & Tan, 2010).

Stephens (2007), when discussing the theoretical attractiveness of participatory approaches in community development, argues that while local participation is increasingly seen as self-evident in interventions, such partnerships have not generally been easy to achieve. In support, he refers to Guareschi and Jovchelovitch (2004): ‘In real settings participation is messy, takes time, and escapes neat definitions’.

Like the solutions envisioned by participatory approaches, the approaches themselves need to be tailored to, and respond flexibly, to complexities that may emerge in local contexts. Therefore, in order to further the knowledge on ways to tackle IAP, and, more broadly, to projects adhering to participatory principles in urban slums, we were compelled to confer due consideration to both solutions and participatory processes. In this study, we examined the application of the co-designing model in two urban slums in India. We explored processes and tools of multi-stakeholder collaboration, and the knowledge that

emerged from them, and its translation into the designing of ICSs. In doing so, we aimed to answer the following research questions:

1. How is the designing process of ICSs affected by the employment of a co-designing approach in urban slums?
2. What does it entail to involve residents of slums in the co-designing process?
3. What does it entail to involve designers in a collaborative, participatory approach?

Methods

Project Exhale

Project Exhale consists of a multidisciplinary team of researchers, designers, engineers and local partners with experience in urban slums development. Its aim is to develop and implement solutions to IAP in non-notified slums in Bangalore, India. In 2014 we conducted a pre-implementation ethnographic study in three non-notified slums with the aim to explore the contextual factors that shape people's choices, views and needs with respect to cooking equipment, and provide potential considerations these entail for projects tackling IAP (Author citation, 2016). Within the practical limitations of time, language barriers and differences in cultural notions, the study found that cooking processes and choices of cooking tools were meaningfully tailored to fit local ecologies, and were underpinned by complex constraints and views towards smoke as a natural part of cooking rather than a source of ill-health. These factors varied widely between and within the three communities, making them unique ecosystems with their own needs and resources. Under these circumstances, Project Exhale, which includes this study, opted to employ a flexible, adaptive and context-conscious approach to the design and implementation of solutions to IAP, with its processes and priorities shaped by local perspectives, experiences and knowledge.

Following the initial study in 2014, two of the three slum communities, situated in the Bangalorean areas Peenya and Sumanahalli, were chosen for project implementation. The selection criteria accounted for the heterogeneity of non-notified urban slums, in order to observe how participatory approaches employed in

distinctive settings potentially lead to different processes and end solutions to tackling IAP. The size of both communities was relatively small, comprising approximately 80 and 120 families, in order to account for the exploratory nature of the approach, and for the human, financial and temporal resources limitations of the project.

Study design

Keeping in line with the flexible, participatory approach of Project Exhale, this study employed an exploratory, emerging and cyclic design. In successive observe-reflect-plan-act (ORPC) cycles (Kemmis, McTaggart & Nixon, 2014) the data collected and the collection methods themselves were reflected upon collaboratively (to different extents) by designers, engineers, slum inhabitants and researchers. Consequently, next steps in data collection and project implementation were decided upon and carried out in the field. Being part of a process-oriented approach entailed that part of our work was to establish, participate in, and facilitate spaces for collaboration and joint knowledge production, in order to address, and create solutions for, real-world issues (Wittmayer & Schapke, 2014). Thus, our role was twofold, of both researchers and project implementers working in a community of practice, which can be understood as multiple actors, with different local understandings and values, who share, and aim to address a common problem (Calton, Werhane, Hartman & Bevan, 2013; Trondsen & Sandaunet, 2009; Wenger, 2000). The need to include researchers in this process stems from the very rationale for this study: to explore collaborations of different groups, stakeholders who in classical, isolating, design models are often engaged with technological solutions without being directly engaged with each other. Thus, we are not only aiming to explore the relationship between actors such as designers and slum communities in the co-designing process, but also acknowledge our role in this network. We would like to move beyond ethnographic discourses which recognise that our presence, as researchers in the field, involves interactions that shape the production and interpretation of ethnographic material (Dwyer, 1982; Krumeich, 1994; Atkinson, 2015). We are deliberately taking up, while also putting under scrutiny, the

active role of agents of change. One benefit of this approach is a more complete account of, and insight into, the processes that generate knowledge. The trustworthiness of the research design is claimed through a rigorous data collection and analysis, which was complemented by triangulation, initially with Exhale's community of practice in Bangalore. For example, through a pragmatic, action-oriented approach, we employed community workshops where we analysed the data gathered during individual interviews, to find mistakes, re-confirm its validity and complement any missing gaps. Following, the data was further discussed between the two field researchers (authors 1 and 3) and the other authors.

Data collection and analysis

This study investigated the first 12 months of Project Exhale which could be broadly delineated into three stages, each consisting of multiple ORPC cycles. In each cycle, different data collection methods were utilised in accordance with the requirements of the project/study at the specific point in time. The first stage involved contacting different local stakeholders, including 8 visits in the slum communities, and conducting informal discussions, unstructured interviews and observations of the living environment and surroundings of the slums. The second stage, consisting of 16 visits in the slums, involved observations of cooking practices accompanied by semi-structured interviews, and participatory activities such as prioritization workshops, community forums and photo voice activities. Finally, the third stage consisted of co-designing activities like building mock ICSs and conducting trials of ICSs prototypes over the duration of 23 field visits. In this stage we did not follow up with all co-designing activities in the Sumanahalli slum due to an unforeseen disease outbreak taking place in the community, which changed the focus of our involvement there.

A key informant who had close contact with, and enjoyed credibility in, Peenya and Sumanahalli slums as an experienced social worker joined the initial community visits and subsequent activities where larger groups of 8-15 participants were mobilised. A verbal informed consent was provided by all participants partaking in the study.

Data was systematically recorded through field notes, audio and video recordings, and was subsequently revisited. First, it was transcribed and analysed as part of the reflection step within each ORPC cycle, when it was shared with other stakeholders and acted upon constructively within the project. Second, and in parallel, it was revisited for this study, as we identified themes inductively and coded the data through an iterative process of data analysis. Not all data gathered will be included in this study, as we focused only on themes related to the ICS designing process and the interaction between relevant stakeholders in this process.

Results

This section broadly delineates the unfolding of the project, and the design and development of the ICS prototype. Furthermore, it gives insight into various associated processes: how and what knowledge was created and shared inside and outside the slums, how decisions for the ICS design were made, and how conflicts of knowledge were resolved in order to reach consensus. Finally, it also sheds light upon other practical challenges arising out of the transience and insecurity that defined the very nature of the slum settings.

Information gathering and knowledge sharing

Initial activities were aimed at developing an efficient community of practice by connecting the main actors that would collaborate for the period of the project. The focus on their equal standing and the importance of context sensitivity were stressed upon, and a two-way exchange of information about Project Exhale and the slums was initiated between the designers, the slum communities and us, the researchers.

In the slums

In order to address issues of context adequacy and sustainability of the improved cookstoves, we invited the designers to conduct field visits in Peenya and Sumanahalli. During these initial visits, they observed that the lay-out and housing structures were substantially different between Peenya and Sumanahalli

slums, thus shaping in distinctive ways the needs of slum inhabitants with respect to cooking space and equipment. Peenya consisted of standardised concrete housing structures laid out in parallel rows facing narrow corridors, built to accommodate a large number of houses in a limited space. Among other implications of cooking outside such as issues of privacy and hygiene (author citation, 2016), the designers noticed that the corridors provided little space for much else, apart from movement and hanging a few pieces of laundry to dry- certainly not enough for cooking. The vast majority of inhabitants placed the *chulhas* (traditional Indian stoves), and cooked inside cramped one-room houses where as many as six or seven family members lived. Thus the designers noted the limited space available in Peenya and the considerations it raised for cooking equipment and cooking areas.

Sumanahalli, on the other hand, was characterised by a more flexible layout of houses, as newcomers built, on the available space, their own housing structures from plastic or asbestos sheets supported by bamboo frames. Here, characteristics of cooking space and equipment varied, as some opted to cook outside, in open spaces, others built small shacks for cooking adjacent to their houses, while the rest cooked inside of their homes. The designers observed that space availability in Sumanahalli was less of a constraint compared to Peenya. However, there were constant alterations in the living environment of people. An indication of the environment's volatility was that in only a few months between the conclusion of the 2014 study and these visits, the layout of the slum had changed considerably with respect to pathways in the community, the houses' dimensions and even their placement within the slum. The designers noted that the constant alterations of the slum's structure and the fragile construction of houses raised considerations for certain types of ICSs such as the lack of infrastructural support for heavy, consolidated, chimney-based stoves and need for easy-to build or lighter, portable ones. In addition, the designers were exposed to complex, heterogeneous 'negotiations' taking place between cooking equipment, and spatial, financial and sociocultural factors: each visit raised further questions pertaining to the development of the ICSs, such as the relationship between family size, amount of food needed and

sessions (Figure 2). Moreover, the information they were exposed to complemented their technical understanding of ICSs and raised important considerations for designing ICSs suitable for the two communities.

Outside of slums

In addition to user needs and knowledge, the designers sought technical information from other sources such as the available literature on the subject and organisations with experience in developing and implementing ICS. An engineer who played a central role in the development of an ICS for a project based in several villages in Karnataka shared his knowledge with us. These were important technical aspects, such as the mechanics of air flow or air suction in chimney-based ICSs, characteristics of flame, the relation between stove chamber and energy efficiency, and issues of ash and soot residue inside of the ICS. He also shared lessons learnt in two context-sensitising activities as part of the rural project, yet his participation and focus in the project could be illustrated by his philosophy ‘first, make the fire happy’, entailing that his foremost attention within the project was to maximise the efficiency of the ICS, with aspects of implementation being the responsibility of a different NGO.

Decision making regarding the designing process

Following the initial visits in the Peenya and Sumanahalli slums we explored ways to reach a consensus regarding the way to move forward with co-designing the ICSs prototypes. The main difficulties encountered in this stage were related to the novel approach and roles that needed to be assumed by both designers and participants from the slums.

The designers proposed to conceptualize a number of possible ICS, which could then be narrowed down to the most promising ones. Next, these would be built and tested, and finally, delivered in the field. They explained that they were accustomed to an approach to product development, whereby a customer reached out to them requesting a certain product, which they would proceed to design and deliver to the customer. The field testing and implementation of the product would be undertaken by the customer,

outside the purview of designers and the ‘laboratory’ where it was created: ‘if they like it, they will use it’. However, after careful consideration and dialogue, a consensus was reached that this step would isolate the slum communities from the development of the ICS and the project. It was also agreed that while it might lead to a functioning ICS design, it would leave unexplored matters of project acceptability and sustainability, and it would not provide an appropriate level of adaptiveness to the ever-changing environment of slums, such as population migration, changing housing infrastructure and other unforeseen factors.

In order to ensure that the community had a consistent presence and voice regarding the direction and focus of the project, and to avoid a prolonged absence from Peenya and Sumanahalli, regular community forums were held in the slums (Figure 3). The main aims of these forums were to discuss with slum residents the information gathered thus far, to define priorities for the project and the ICSs, and to decide upon ways of meeting these priorities. We recounted with them smoke-related discomforts, fuel accessibility and cost,



Figure 3. Animated prioritization workshop in front of a tea-shop in Peenya

space availability, cooking time and cooking needs. Moreover, they identified gaps in our data gathering such as missing out on the dangers and discomfort caused to infants when mothers cooked while carrying them in their arms, the physical burden of carrying large heaps of firewood from a nearby factory in Peenya on a weekly basis and the reduced visibility when cooking due to lack of natural or artificial lighting. The group discussions helped with reaching a consensus over the priorities that we, as a community of practice consisting of the designers, end-users and researchers, should be focusing on. The main priorities differed in the two slums. In Sumanahalli, the main focus was upon financial aspects: affordability of the ICS and reducing fuel usage, while reducing smoke released by the stove was a

secondary issue. In Peenya, on the other hand, where smoke was difficult to ventilate and options to cook outside were limited, smoke-reduction was the primary issue that respondents hoped to address, while reducing cooking time and financial costs were seen as secondary priorities.

The ensuing activities were aimed at reaching an agreement on the way to move forward with the project and meet priorities. We conducted exercises where we discussed potential materials and designs for the

ICS by employing visual cues of concepts. However, the conceptualization exercises led to little progress and proved to be too abstract and ineffective, necessitating the use of more tangible approaches. We asked the participants to build 'ideal' stove prototypes with the use of foam bricks, plastic pipes and cardboard (Figure 4). However, we observed that the 'ideal' stoves built were mere reflections of the *chulhas* the residents of Peenya and Sumanahalli slums were currently using, which, the designers reasoned, was due to the slum inhabitants' internalization of the cooking equipment and cooking experience over the course of many years of practice. In spite of the initial difficulties in finding



Figure 4. Participant building 'ideal' stove from foam bricks and other materials

ways to move forward with the designing process collaboratively, the activities served as a platform to examine underlying reasoning behind certain characteristics of the traditional *chulhas* as well as acting as platform to discuss ideas put forward by the designers.

Prototyping

Unfortunately, subsequent co-designing activities in Sumanahalli were obstructed by a severe disease outbreak during the monsoon period, which impeded further community participation in designing an ICS, and re-directed our efforts towards dealing with this issue rather than move forward with the ICSs. In Peenya however, with the lessons and information gathered in the previous phases in mind, we adopted

a non-disruptive approach to ICS development. In order to avoid shifting the centre of activities outside of the slum, we used an unoccupied house in Peenya as a makeshift laboratory for experimentation, with the consent of local slum leaders. There, rather than introducing a ‘foreign’ product, far from the ‘ideal’ versions of stoves built during the foam modelling workshops, we encouraged slum residents to build several *chulhas* similar to the ones used in their own homes. From this starting point, the designers made small, cumulative technical modifications to the *chulhas*. These changes were complemented upon during workshops by feedback from people in the slum, who were encouraged to cook on them and share with us feedback regarding their usability (Figure 5). By building upon the *chulhas* constructed by residents in Peenya, a sense of ownership over the process was instated, as the women involved were curious about the changes made to *their own chulhas*. In addition, we left the house key with a woman living in its vicinity, who could let in anyone who wanted to try the stove at their own convenience. For trials, we provided participants with ingredients bought from local markets which they used for habitual dishes like dal, rice, chapatti and sambar. They used their own firewood in order to account for the specific types of wood that are locally available.



Figure 5. Two participants using and discussing the characteristics of two different prototypes

The first co-designing cycle in this stage built upon the priorities envisioned during the previous workshops and on the *chulhas* built in the ‘lab’ by the participants. With minimal changes in dimensions, the designers placed on the *chulhas* metal tops connected to concrete pipes that

would redirect the smoke outside of the living space (Figure 6). Users noted a certain reduction in smoke released inside the lab, however, the construction was rudimentary and the stove still released an amount deemed uncomfortable by the cooks. This step, however, marked the beginning of multiple cycles of co-designing by our community of practice. The changes included ideas regarding comfort, requirements of

different cooking recipes and stove efficiency as indicated by users. At the same time, technical aspects were added in the prototype, aimed at decreasing the release of smoke and increase the efficiency of the stove, as indicated by engineers, designers and participants from the slum. With each new prototype, components were included in order to increase efficiency, such as grates for ash and soot, and inner flanges to better direct the smoke and energy produced during cooking or increase the height of the prototype (Figure 7). Concomitantly, users raised specific needs which needed to be incorporated in these

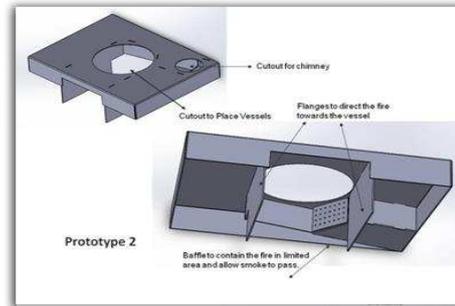


Figure 7. Gradual changes to the top are made, to better contain fire and direct smoke towards the chimney. These changes were discussed with the participants during the slum laboratory trials.



designs. They required adjustments to the size of the metal top to account for larger vessels used to cook chappati and roti, and add pieces onto hobs that allow cooking different dishes. Furthermore, based on their comments, we changed the size of the cooking chamber and the entry point for wood. This created several advantages, such as an increased visibility of the flame, easier flame control and allowed the use of differently sized wood pieces.

Reaching consensus in ICS development

When discussing technical alterations with the users, they generally agreed with the changes, or they helped us reach a balance between what would be acceptable both in terms of usability and efficiency (Figure 8). For example, agreeing upon a wood entry high enough as to allow a minimum level of visibility yet ensuring that the air draft is not negatively affected or that smoke does not escape through the entry. In some cases, however, technical aspects were not readily accepted by users, and they would provide feedback that ran against the technical views of designers. An illustrative example was whether

we should add small knobs around the prototypes' hob, onto which the vessels would rest during cooking- a component they normally added on their traditional stoves. The users' reasoning for this addition was that the fire needed to escape from the stove chamber and engulf the sides of the pot for an increased efficiency. It could also be argued that this space would permit an air channel within the fully enclosed traditional clay chulha. On the prototype they were using, however, the required oxygen supply was provided through the inner workings within the stove chamber which were



Figure 8. Two designs: The first, (top) built for maximum visibility released more pollution, and the second (bottom) contained the smoke better but conferred poorer visibility of flames during cooking

connected to the chimney. Moreover, the designers argued, a space between the vessels and the stove top would provide an escape route for the heat contained in the chamber, rendering the prototype less

efficient. The consulting engineer explained that in his experience, users observe benefits of stove efficiency only through long-term use, as compared to smoke reduction which is more easily observable, due to many other factors affecting stove efficiency such as quality of the fuels and climate changes.

In a subsequent meeting, we decided with the designers that while they could enforce their view upon the development of the ICS, this would not only undermine the users' position within the community of practice but it could also raise implications for the sustainability of the project itself. As we aimed to ultimately establish a community-based model for the construction and distribution of the ICSs within the slums, it was reasoned that the local constructors or even users of stoves might make further changes to the ICS based on their technical views and understandings. Therefore, we concluded that it would be desirable to conduct long-term trials of prototypes with different technical characteristics accompanied by discussions, as they could help us, as a group of equal standing stakeholders, reach a consensus upon what are the most efficient technical aspects for the prototype. However, using the 'lab' as a 'lever' to do so was soon impeded by the demolition of the workshop, alongside several other empty or inhabited houses, in an attempt by local authorities to clear the land upon which the slum community resided.

Moving the prototype outside of the community

While not ideal, the stage reached thus far in the co-creation process was an ICS prototype sufficiently acceptable to users in terms of comfort and usability. In addition, during trials, participants made favourable comments about the reduction in smoke released inside the 'lab'. The efficiency of the stove was yet to be established by either us or the participants, particularly in light of a late monsoon season severely affecting the quality of wood and workshop environment. Some of the participants wished to install the prototype inside their own homes. However, the prototypes at that stage were made in metal and became dangerously hot during cooking, thus posing a risk of burns for those cooking, the infants in their arms or their children who often played around the cooking areas. Therefore, we decided to relocate the prototype to a more controlled environment- a shed resembling housing structures in Peenya, yet,

outside the reach of the community. There, and at the conclusion of this study, we begun to explore replacing metal with other materials, which would allow participants in Peenya slum to test the prototype in their own homes for longer periods of time.

Discussion

The purpose of this study was to analyse a participatory approach aimed at developing context sensitive solutions to IAP in two Indian urban slums. It focused on two main points:

1. Investigating the development of ICSs through a co-designing approach
2. Exploring the processes that emerged during the multi-stakeholder collaboration entailed by the approach

The main stakeholders that collaborated for most part of the project were the slum community, the designers, and us, the researchers who acted as a catalyst among them and other actors.

Co-designing an ICS

The results indicate that employing a participatory approach in urban slums can generate contextual knowledge that facilitates and successfully feeds into the ICS co-designing process. The designers' background and technical understanding brought onto a common platform with the slum inhabitants' knowledge of their own experiences and environment led, at times, to lines of inquiry and consequent findings that, arguably, would not have emerged in a rigid prescriptive technology model common to large-scale, top-down approaches to technology development (Sesan, 2014). Starting with the initial stages of our community-based activities, considerations were drawn that helped narrow down different types of ICSs that might be suitable for each slum. These considerations were reiterated and complemented upon during the prioritization workshops where participants expressed their needs regarding stoves, cooking and smoke.

Co-designing activities painted a more complex picture of the relevant requirements of stoves than is generally emphasised in the literature. The two communities had to weigh and negotiate stove

characteristics in relation to their specific living context. In this light, what are traditionally seen as barriers to ICSs projects' implementation are becoming part of the discussion with the community, thus reducing the risk of product inadequacy post implementation. Reduction of stove cost, for example, which is ever-stressed in literature as a way to make ICS more attractive, was viewed differently by the two communities. As the effects of smoke were more acute and difficult to avoid in Peenya, people were prepared to invest additional resources in a stove that could reduce smoke exposure in a more efficient manner, as compared to Sumanahalli, where they had more flexibility in terms of cooking space and ventilation, and where they preferred cheaper stoves. In a sense, participation tools reversed the processes of marketing the product. In a more traditional model, the implementers would try to persuade the community of the benefits of stoves in relation to its cost. In the process of co-designing, the community itself is responsible for rationalising the benefits, or characteristics, of the stove in relation to the costs of its manufacturing, thus providing an assessment closely grounded in the realities of people. The comparative experience of employing these methods in two communities highlighted the way in which different negotiations, regarding stove characteristics, were made by people through the co-designing process, reinforcing the potential of the model to attune solutions to local requirements.

The co-designing activities in the slum laboratory led to a gradual translation of technical, cultural and social aspects into the ICS prototype. This stage helped the designers and participants from the community reach common understandings of these aspects, whether they were issues of comfort and usability or technical changes. Moreover, it helped strike a balance agreed upon by both actors, between different characteristics built into the stove.

The co-designing process was rarely a straightforward matter of feeding knowledge held by different stakeholders into the design of the stove, as the tools and methods of sharing information (seen as a two-way process) had to be continuously adjusted, even improvised upon, in order to facilitate the collaboration between the slum inhabitants, designers and us. Hussain et al (2012) underscore that it is

important for the researcher/designer to adopt a more facilitative role and hand over the creative reins to the participants. That this is challenging to achieve was evident in both their study of a participatory-design project in a marginalised community in Cambodia, as well as in project Exhale, where during most activities, participants were hesitant to take creative initiative when interacting with the designers. To address this barrier, Hussain et al recommend fostering and increasing participants' confidence in their own designing capabilities when employing co-creative activities. In the case of Exhale, participants showed most initiative during hands-on activities centred around cooking on, and discussing aspects of the stoves, which were regarded as their 'domain', in contrast to more abstract activities. This finding is in line with the approach maintained by the NGO 'Practical Action' towards the development of technological solutions for the marginalised: 'starting from the existing skills, experiences and resources of local citizens' (Sesan, 2014). In Exhale, the starting point in physically developing the ICS was literally the traditional stoves used by slum inhabitants, built and further developed inside of a slum house (the slum-laboratory). By doing so, it aimed to account for the cultural, social and financial considerations of cooking practices, space usage, housing infrastructure, and local resources such as materials and fuels. At certain points during the co-designing process in the slum laboratory, differences in technical views of users and designers surfaced. It could be argued that one of the strengths of co-designing approaches lies in the interpretive paradigm assumption that knowledge is socially constructed by human actors through shared meaning (Willis, 2007). In this view, competing beliefs could be reconciled, and new, shared technical understandings regarding the ICS would be reached by the community of practice. This process necessitates long-term communication, knowledge sharing, and usage within context of prototypes encompassing different technical aspects (rather than imposing one view over the other, different views should be considered, assessed, and decided upon). We can draw parallels regarding the need for consensus on competing beliefs with a case study of a community-based ICS project by Rose (2002), which highlights the importance of understanding technical principles that lie behind design components

by those installing the stoves: 'knowing the reason for (rather than just existence of) a given aspect of design can lead to more accurate construction'. We would like to further this view with two points. First, we argue that not only those who install the stoves (field workers) need to understand these principles but more importantly, users have to. They are the ones deciding upon the adoption of ICS, and, furthermore, such an understanding can be a response to studies that found that users often make changes themselves to the stoves, post-installation, based on their own views (Barnes et al., 2012; Palit, D., Bhattacharyya, 2014). Second, we argue that pre-determining the relevant principles outside of the community is a preventive half-measure. In our experience the relation between stove components and efficiency principles as seen by the communities and that need 'elucidating' is often unexpected. Actually, even Rose's argument is based on an episode when the need to explain principles arose when a field worker held different views about a stove's technical component during a stove installation. Thus, it was actually an in-the-field conflict that led to discussing and elucidating technical principles of ICS. This points to the importance of incorporating in the co-designing process an active looking for, and reaching consensus on, technical principles.. Ultimately, the question of whether further co-designing activities would lead to a complete reconciliation of all conflicting technical beliefs remained unanswered at the conclusion of this study, as an unforeseen evacuation by authorities of a portion of the Peenya slum led to the demolition of Project Exhale's makeshift laboratory.

In Sumanahalli too, a disease outbreak during the monsoon season postponed Exhale's co-designing activities. The systemic uncertainties faced by inhabitants of non-notified slums represent another significant way in which participatory approaches in these settlements parts ways with those in other contexts. In order to not only attain sustainable results, but also to even conduct co-designing activities towards the amelioration of IAP, there is a need to acknowledge and address broader, systemic conditions. As they call for a project flexibility that needs to be assumed to a much higher degree than it

would be expected in more stable environments, these complexities, and ways to account for them need to be further explored.

Collaboration in a community of practice

Fostering a community of practice entailed, for all the involved actors, a departure from the well-established roles they were accustomed to, in favour of more loosely defined ones: at different points in time they played interchangeable roles as project planners, implementers, researchers, designers and users of prototypes.

An important medium of change within this process was crossing the spatial boundaries conventionally attributed to the stakeholders, namely, the slums, laboratories and offices. Moving the laboratory into the slum, where its inhabitants had access to and could make use of it at any time, and where their role was to provide expert knowledge and make project-related decisions in collaboration with us and the designers, blurred the traditional deliverers-recipients delineations and increased community ownership over the project and development of the ICS. In such community-owned spaces, constantly sharing with the participants the data gathered and progress made, played a similar part in the generation of knowledge. As part of a community of practice, the designers too went through a process of transitioning from their customary approach to design towards a more flexible, participatory one. Their presence in the slums led to their 'instinctively' undertaking interviews, observations and active roles in workshops, and enabled their metamorphosis from mainly a technical interest in ICS designing, towards issues related to project implementation and sustainability.

Our role as researchers similarly departed from its more traditional forms. We not only collected data, but had an active role in the development of the project, and in the generation and exchange –thus its translation- of knowledge by different actors. Due to the exploratory nature of participatory methods, at any given time there were different possible ways of moving forward with the project. In some instances, more orthodox design approaches were debated in the community of practice, as it seemed easier to fall

back on more straightforward and pre-established models, endorsed as the safer way to reach targets, less time-consuming and possibly less resource-consuming. Therefore, an important part of our responsibilities was to try to ensure that local knowledge retained its centrality in the designing process, and facilitate the collaboration of involved actors from an equal position, as per the principles of the co-designing approach. This entailed a constant 'watch' on aspects of representativeness, involvement and shared decision-making, which were sought through negotiations and rationalizations with the other actors. This process compelled us to go beyond normative reasoning, beyond pushing participation as intrinsically the right thing to do. Instead, this experience taught us to explore and develop more pragmatic argumentations – to show how and why equal collaboration would be the more coherent way to move forward, for instance.

Participatory activities blurred the lines between stakeholders' roles and power relationships within the project, and created a sense of ownership over the project processes to a certain extent. However, they did not succeed in removing these lines. The fact that we were the 'watchdogs' of democratic processes within the project, while the community did not uptake an active role to ensure their own representativeness, is an indication of the power discrepancy between stakeholders. Ultimately, most final decision-making with respect to the direction of the project took place outside of the slums, and most activities, especially in the initial phases were mainly directed by the designers and us. Similar limitations to community participation were identified by Hussain et al. (2012) during the co-creative project in rural Cambodia. Hoyer, Chandy, Dorotic, Krafft and Singh (2010) argue that the desire and ability of users to play a greater role, through co-creation, in the development of new products is seen as an outcome of an increased consumer empowerment. This implies that in instances of disempowered consumers, they will lack the experience with, and have a diminished propensity for, active participation. In support, Puri, et al. (2004) stated that participatory approaches developed in Western contexts are not easily transferred to resource-limited settings in India, due to its different historical, political and social contexts. To attune

them to the needs of the context, such models have to arise from the realities of the context: to ground activities in the experiences and knowledge of people whenever possible, and to look at participation not only as a means to develop a technical product, but as a means to develop actors' ability to express and create in a common space. This shift in perspective, entailing a possible departing point from co-designing in Western contexts, can legitimize activities oriented more explicitly towards collaboration and towards exploring avenues for a more community-directed participation.

In conclusion, while it was beyond the scope of the study to assess the long-term success and sustainability of the project, our experiences indicate that co-designing can lead to solutions grounded in the realities of slum inhabitants, shared ownership over processes and products, and higher acceptability of ICSs, as indicated by the responses of participants. However, in order to take advantage of the potential of co-designing, implementers need to expect, and be prepared for, a higher degree of flexibility than would be required in less marginalized communities. It is also imperative to recognise that contextual aspects such as an experience of western education systems, and stable income and infrastructure, embedded in western models of participation like co-designing, may pose novel barriers when transferred to such drastically different settings as the non-notified urban slums in India. Consequently, tools to facilitate multi-stakeholder collaboration need to be continuously adjusted to facilitate information sharing and increase the actors' creative and collaborative capabilities. This, in turn raises considerations for temporal, financial and organisational planning, and forms the rationale behind employing activities for building capacity for collaboration by and in marginalised communities.

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