Onboarding Communities to the IoT

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Abstract. With the advent of the Internet of Things, low-cost sensing technologies are becoming increasingly available, allowing citizens to collectively monitor and share data about the environment. A subset of these technologies is being made at maker spaces, using open source and affordable technologies. While these systems have the potential to power bottom-up participatory data networks, a key concern is that laypeople often fail to effectively setup and connect these sensors to the Internet because they lack technical skills and/or the systems' user experience is poorly designed. We present a novel onboarding application that aims to facilitate the process of sensor setup and connection by non-experts. It works by providing an integrated design experience, scaffolding the complexity of the process, and guiding the user in a conversational fashion. We hope to inspire other developers and designers to consider the needs of non-technical and diverse communities in the design of IoT systems.

Keywords: Digital social innovation platforms · Crowdsensing · Internet of Things · UX · Design

1 Introduction

In the past decade, the proliferation of open source technology such as Arduino, the creation of makerspaces and Fab Labs [13], and the growing popularity of crowdfunding platforms have fostered the design of new sensing technologies that allow citizens to collect and share all sorts of data, from temperature and humidity [3], to air quality or noise pollution [9] and nuclear radiation [14]. These new technologies aim to empower self-organised groups of citizens by providing Do-it-yourself (DIY) or more open systems that they can appropriate to tackle matters of concern, learn about technology and/or the environment. Notable examples are the Air Quality Egg (airqualityegg.com), Safecast (safecast.org) or RadiationWatch (radiation-watch.org).

While these novel and affordable technologies could foster the emergence of new forms of environmental monitoring, empowering citizens to collect, share and use data in their own terms, previous studies have revealed a number of technical and social issues that can hinder the appropriation of sensing practices at the grassroots level [8]. A key concern is that laypeople often fail to effectively setup and connect these sensors to the Internet because they lack technical skills and/or the systems' user experience is poorly designed [2]. Naturally, failing to set up and connect a sensor often leads to frustration and disengagement; and to a missed opportunity to contribute valuable data.

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How can low cost sensors be useful and engaging for laypeople? How can this technology, which was traditionally designed to be used by experts, be *enchanting* [15] for the general public? In this short paper we present a novel onboarding application for the Smart Citizen Kit, a crowdfunded open source sensor kit for environmental monitoring that was designed at Fab Lab Barcelona [9]. The application facilitates the process of sensor setup and connection by non-experts. It works by providing an integrated design experience, scaffolding the complexity of the setup process, and guiding the user in a conversational fashion.

We followed a participatory research through design approach to collaborate with community participants who were involved in a citizen sensing intervention aimed to tackle noise pollution in Barcelona. We here present how the process led to a novel open source application that can be readily appropriated by developers and designers working towards the design of engaging and user friendly IoT systems.

2 Background

Researchers and practitioners have studied many aspects of participatory sensing systems, from technology design and features to people's motivations to participate in citizen science and issues around data sensemaking [1, 5, 6, 24]. A large proportion of these findings refer to either citizen science projects or research studies where participants have been recruited to collaborate with experts and or facilitators. In consequence, there is little reference to the factors associated to the appropriation of participatory IoT and sensing tools at the grassroots level. How should such tools be designed for laypeople and grassroots communities to be able to autonomously use and profit from them?

It is important to consider that there are key differences between traditional Information and Communication Technologies (ICT) and the more novel sensing and IoT technologies. While personal computers and mobile phones are pervasive in everyday life, sensing technologies are still novel and largely unfamiliar to most people [8]. Until recently, sensing technologies tended to be embedded into existing products and the environment, which meant that the public had little access to them. This unfamiliarity with the technology and lack of skills to operate them can have an impact on how effectively people engage in data collection processes. Moreover, low-cost tools are sometimes still unreliable and hard to use [23].

Following participatory approaches to design novel sensing technologies can foster acceptance and appropriation. For example, DiSalvo et al. [8] introduced sensor and robotic technologies to residents in a neighbourhood, organising a set of activities such as scenario writing and mock-up development to inspire people to envision novel applications of the devices. As a result, the participants gained familiarity with the technology and appropriated it in ways that had been unanticipated by the researchers.

Next, we describe how we designed a new IoT onboarding application in collaboration with users. The application comprises assembling a Smart Citizen Kit device and its enclosure, configuring and naming it, and subsequently connecting it to the Internet to relay data to an online platform. The aim was to elicit people's preferences to co-create a system that makes it easy for users to engage with crowdsensing campaigns by learning how to deploy a low cost sensor. Furthermore, rather than trying to design a complete *plug&play* solution, we aimed to support the development of technical skills in users, by requesting that they assemble their own sensor and make sense of the setup process [19, 21].

3 Smart Citizen

Smart Citizen is an open source sensing platform that comprises a sensor kit (SCK), an online platform and a mobile application. The project was launched in 2012, instigated by the Fab Lab Barcelona [9]. The SCK consists of an Arduino-based electronic board and shield, a battery, a Wi-Fi antenna, a MicroSD card, and a set of sensors to monitor humidity, temperature, nitrogen dioxide, carbon monoxide, sound, and light. The SCK firmware is created to read, process and post this data, as well as battery charge level, intermittently upon setup. The online platform (smartcitizen.me) allows users to upload data from their SCKs, this is either automated through the kit or through CSV to share them online. Both the sensor kit and the online platform were developed with financial support from users through two crowdfunding campaigns.

From the 1200 SCKs that have been delivered to users around the world only a small percentage of these sensors (less than 20%) are kept online, contributing data to the Smart Citizen platform. Previous research has shown that users struggle to connect their SCKs to the Internet [2]. Informants explained that they found the process to be too long, confusing, and tedious. They also highlighted the need to have access to accessible documentation and troubleshooting advice to assist them while setting up their devices. While SCK does provide a place for such documentation, this experience is segmented and often complex for a non-technical audience (Fig. 1).

Fig. 1. The Smart Citizen kit, mobile app and data visualization platform.

4 Collecting User Requirements

We followed a participatory research through design approach to the development of a new onboarding application [25]. This method involves following consecutive iterations and evaluations to frame the problem and improve some characteristic of the studied phenomenon [12, 17], in our case, we focused on the onboarding experience to the Smart Citizen Kit by non-technical users. The aim was to collaborate with users to gather usability insights and co-design a new experience that was engaging and user-friendly, and allowed users to assemble a device, set it up and connect it to the Internet via Wi-Fi by themselves.

Three think aloud sessions with 27 community participants who were participating in a citizen science project but had never used a Smart Citizen Kit before were organised. This method requires that the participants talk aloud while performing a task [10]. Two sessions were individual (one participant in each), and a third was a group session with 25 participants who worked in groups of three. The sessions were held at the lab where participants were given pouches comprising a disassembled SCK, a USB cable and a 3D printed enclosure, and asked to assemble and install the sensors using their computers. Two observers took notes of how users performed the task and annotated verbatim. The collected data was analysed by two coders [4] and used as input during co-design workshops. The emergent issues were later synthesised under three themes: complexity, engagement, and hardware.

Complexity

Fragmentation: We identified that, if completed with no deviations, the installation process of the Smart Citizen Kit had a minimum of 20 tasks, some consisting of multiple steps. Often these tasks led to dead ends, or were largely unsuccessful for different reasons - e.g. lack of connectivity, no existing user account, etc., - which meant the user would have to restart the whole process.

Lack of signposting: Participants found the setup process to be *"too long"* and lacking status updates that helped them make sense of the stage of the process in which they were. Steps of the installation were seemingly out of context, asking users for potentially invasive information without an accompanying justification.

Engagement

We found that personal details such as exact location, name, email, etc. was the kind of information that participants least liked giving out and would most often question. Moreover, documentation was both difficult to find and difficult to troubleshoot. This often created confusion, disengagement and led to abandonment.

Language: Participants found the language used in the Smart Citizen platform too technical. They often found themselves wondering what key terms meant and confused on how to proceed with the installation process.

Hardware

The installation process required the use of a micro USB cable, which provided an obstacle for those who did not own one. This also made it difficult for people to install the device on a mobile device such as a phone or tablet, therefore limiting installation to a physical experience of using a computer.

5 A New Onboarding Experience

Two co-design workshops with two developers, one user experience designer and community participants were organised at the lab. During the workshops the themes resulting from the think aloud sessions were analysed and discussed by participants, designers and coders. The ambition was to design an onboarding experience that would increase the ratio of successful installations by reducing the complexity in signing up and fostering user engagement.

As a result, a number of prototypes were developed, tested and iterated in collaboration with community participants. We addressed complexity challenges by restructuring and condensing the sign up experience, harnessing the completeness effect [22] and introducing a progress bar. We fostered a sense of engagement by creating a sense of device ownership and developing a friendly visual and written language. Finally, we tackled hardware issues by creating a seamless experience where users do not need to use a USB cable or external assets during the installation process. Next, we present the onboarding application[1] and describe how we addressed these themes (Fig. 2).

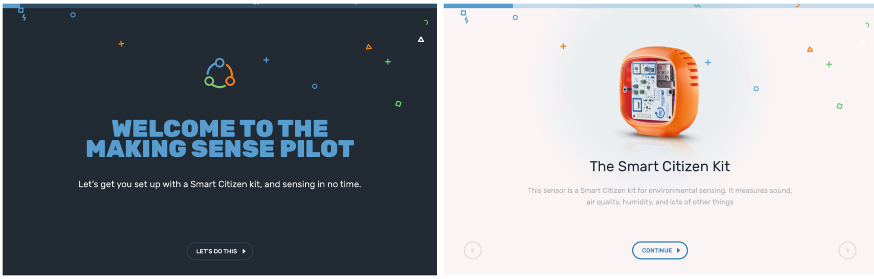

Fig. 2. Screen captures of the onboarding application.

5.1 Complexity

Restructuring and condensing the sign up experience. The installation sought to create context upfront and scaffold the complexity, leaving the most monotonous tasks towards the end. This took into account the Goal Gradient effect [7], whereby users efforts towards a goal increase as the proximity to the goal increases. The geolocalisation of the sensor, creation of account and submission of personal details were all moved to the end of the user journey, thus rendering the risk of a wiping out the effort if details were denied. The final, user detail, submission process essentially finishes the installation and redirects users to the Smart Citizen platform.

Completeness. The tasks were also compartmentalised in complexity. Each task was broken down into an appropriate number of steps that balanced ease of use with complexity, and difficulty with stagnation to create a continuous sense of flow [20] and progression. As each of the larger goals were broken down into steps, the larger goal was found to be less daunting, and easier to accomplish. By packaging these tasks as part of the larger goal we seek to provide a perspective of importance of the entire

[1] onboarding.making-sense.eu and https://github.com/MakingSense-EU/onboarding-app.

onboarding process. This harnesses the completeness effect [22], where by showing parts as being incomplete of a greater whole, more consumption of such parts takes place.

Progress bar. We paid special attention to visibility of system status and signposting. A progress bar, as well as constant feedback brought context to the tasks being undertaken and effectively broke the end goal down into achievable steps. The idea was to visualise each step (goal) as simply as possible to increase chance of completion [16].

5.2 Engagement

Creating a sense of device ownership. To foster a sense of ownership [2], and support the development of technical skills in participants, we designed the task of physically assembling the SCK device as part of the onboarding experience. This task did not exist in the previous onboarding system although SCKs are bought disassembled and instructions are hard to find. In the new onboarding experience, the assembly was outlined in the installation instructions and treated as importantly as the digital setup itself. Coupled with the ability to do seemingly trivial things such as naming the sensor, this assembly and 'life giving' to the device by the participants can contribute to fostering a sense of value, ownership and attachment to the physical device [18].

Creating a friendly language. Another improvement was in the written and visual language of the user journey. Previously the installation had been confusing due to the overtly technical nature of the language used, as well as the poor signposting. When components were referenced by name, participants had little choice but to guess as to which components were referred to. Simplifying the language, provided we educated when needed, can breed trust within the experience [11] and strengthen engagement.

The improved onboarding features a photographic and iconographic-based approach where each component and method of assembly is represented and needs to be accounted for before progressing. On each of the components a link for a more detailed description is provided-with the idea of familiarising participants with the basic technical components to facilitate the assembly and troubleshooting processes (Fig. 3).

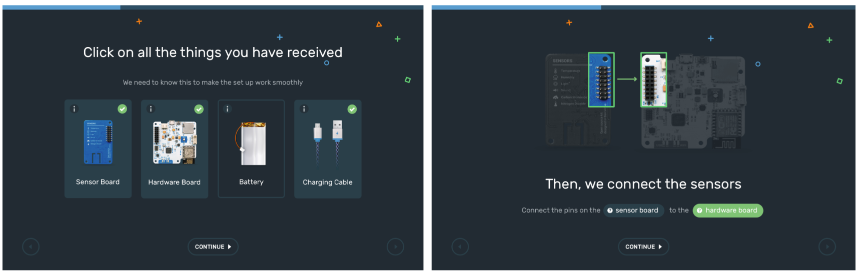

Fig. 3. Sensor hardware and assembly.

5.3 Seamlessness

Optimised for devices & removing the need for hardware. The process of syncing the SCK device with the platform was the hardest one to solve, as all the routes investigated had some degree of complexity or potential risk of failure. The original installation was executed via a USB cable, and the installation of a browser extension, via which the data was transmitted. With the aim of condensing the installation into a single process and reducing the reliance on collateral hardware, a mechanic was designed to transmit the device credentials to the platform using the embedded light sensor in the SCK sensor board.

The light sensor captures RGB (additive light values). Using this input we were able to divide the usable alphabet, numbers and symbols into grey-scale values. The light sensor is used as a way to easily measure grayscale. This makes it possible to transmit values representing characters, which make up the WiFi SSID and password the user previously enters to connect the sensor to their network. The handshake process itself begins when the sensor is waiting for configuration and is presented with the initialisation process. The sensor needs to be placed in front of the screen with the source of the grayscale handshake SVG area.

This approach allows for the potential of any device with a modern screen both matte and gloss to handshake with the sensor given the screen itself is placed directly against the light sensor. It is important to note that in order to minimise errors in this process, proximity and brightness of the screen are imperative to lower the risk of passing corrupted characters. The onboarding process was optimised for a variety of devices. Users can therefore benefit from the same experience whether they are on a desktop computer, a laptop or a touch device by using this seamless 'light handshake'.

5.4 Tech Stack

When planning and building the technology stack, scalability through abstraction and portability was the goal. It was decided that the application should run in AngularJS providing itself as a JavaScript bundle upon page load. Unlike the previous onboarding this one is constructed separated from the SCK platform. This application serves to provide modularity through service oriented architecture (SOA) in application and appropriation through open source technology. Refactoring and releasing new developments on the onboarding can be scaled with this approach. A modular onboarding is entirely dependent on available and public APIs of its parent project, which drives developers of said project to open and document their endpoints.

Additionally, the application is structured as a wizard. There is one large HTML frame, providing heading and footer content accordingly, where the internal body structure is updated to present different steps required by the user. These steps, through an animation framework built for the project, ease and animate so as to give the appearance and experience of interactive page loads while simply calling JavaScript to update HTML. These body views are constructed in reusable code, where possible. These views are populated before page presentation, from a separate JSON array, and animated with respective easing, accordingly. This approach of code abstraction into a JSON object allows for individual manipulation of the page contents or views without the need to alter the other (Fig. 4).

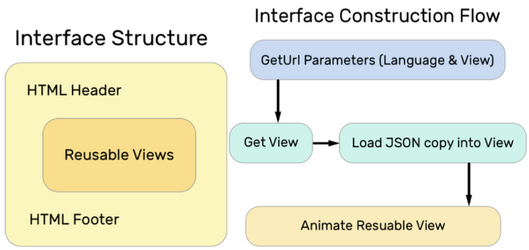

Fig. 4. Data structure.

6 Conclusion

New low-cost IoT devices are becoming more pervasive in everyday life, democratising access to data collection, sharing and analysis. With these tools people can join citizen science and sensing initiatives to address environmental threats and/or urban challenges. However, IoT devices are still largely unfamiliar for laypeople with low technical skills or often poorly designed in terms of usability. There is a need to make sense of user needs and requirements to design more usable systems that people can independently appropriate and use for their own purposes.

In this short paper we have presented a new onboarding application that aids the setup and installation process of a Smart Citizen Kit. Its design rationale aimed to address issues of complexity, engagement and hardware that were evidenced through think aloud usability sessions conducted with community participants who are part of a citizen science initiative. We found that following a participatory approach to design this application with and for communities was a fruitful method to elicit real needs and aspirations, and to create an engaging onboarding experience. The application is modular and open source to encourage external appropriation hoping to inspire other designers and developers of IoT systems.

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