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Citizen engagement and collective intelligence for participatory digital social innovation

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Highlights

- Digital social innovation shares the basic ideas of citizen science, as well as the common challenge of motivating and structuring citizen engagement. However, it is different in scope, focus, forms of participation and impact.
- Digital social innovation explores new models where researchers, social innovators and citizen participants collaborate in co-creating knowledge and solutions for societal challenges.
- There are critical issues and effective practices in engaging citizens as knowledge brokers and co-designers of solutions to societal challenges, which should inform the design and implementation of new projects and approaches.

Introduction

As citizen science matures, it finds itself part of a growing plethora of approaches democratising the processes of scientific enquiry and related modes of knowledge creation. Digital social innovation (DSI) and do-it-yourself (DIY) science are two examples that share citizen science's ideals and challenges of enabling citizen engagement (see also Mazumdar et al. in this volume). Considering typical challenges and types of citizen engagement models in DSI and DIY science, and how such platforms relate to approaches in participatory citizen science, may help the fields to learn from each other and inform new projects and approaches.

In citizen science (Bonney 1996; Cohn 2008), citizens are commonly involved in different types of activities in scientific projects, which are mostly led by professional scientists in institutional settings (Bonney et al., 'Public Participation', 2009; Shirk et al. 2012). The underlying assumption of science as the primary legitimate source of knowledge requires citizen participation to conform to the scientific process (Wyler & Haklay in this volume). More flexible forms of engagement relax this requirement by giving citizen participants more influence on the project design (e.g., in the choice of problems or outcome types) and empowering them to collaborate with different actors, among which scientists are but one kind (see also Ballard, Phillips & Robinson in this volume). This broadens the scope of projects, their goals and outcomes, and the types of activities performed by citizens. In particular, participatory citizen science and 'extreme citizen science' (Haklay 2013; Stevens et al. 2014) emphasise citizen involvement in core activities of the scientific process, such as problem definition, data analysis and interpretation (see also Gold & Ochu in this volume). These projects design tools for empowering participation from different societal groups (e.g., marginalised communities) in activities that would normally require scientific skills and knowledge. In doing so, they bring scientific enquiry to 'non-scientific' problems (e.g., problems important to the volunteers' communities) and 'non-scientific' knowledge (e.g., indigenous knowledge, local needs) (see Danielsen et al. in this volume).

Do-it-yourself science extends this to more informal, experimental methods and a broader range of outcomes: DIY scientists are people who create, build or modify objects and systems in creative ways, often with open source tools, and who share the results and knowledge (Nascimiento et al. 2014, 30). This includes non-specialists, hobbyists and amateurs, but also professional scientists doing science outside their traditional institutional settings. Many DIY science projects are private or community-based initiatives that use scientific methods combined with other forms of enquiry to explore techno-scientific issues and societal challenges (Nascimento et al. 2014; see also Mazumdar et al. in this volume).

This openness to different types of knowledge, outcomes and social settings is also part of the field of social innovation, which emphasises the societal impact of both scientific and practical knowledge creation. The concept of social innovation commonly describes novel solutions to social problems that are more appropriate than existing ones (e.g., more effective, efficient or sustainable) and that create value for society as a whole (Phills et al. 2008, 36). Many social innovations are increasingly based on the use of digital technologies, such as social networks, open data, open source hardware and software. Such digital social innovations are often defined as new solutions to societal needs developed through collaboration between innovators and target users, supported by digital technologies (Bria et al. 2015, 9). This resonates with an early view of citizen science as a science that addresses the needs of citizens and involves them in the scientific development process (Irvin 1995, xi). Such views of (participatory) citizen science and social innovation thus converge in the goal of producing knowledge that addresses societal needs.

A key commonality of participatory citizen science, DIY science and DSI is the focus on citizen engagement with different professional actors in a process of collaborative development and knowledge co-creation, in other words, a process of collective learning. Ideally, they all aim at engaging individual citizens and local communities in the entire process of scientific, exploratory or creative inquiry: from the problem definition and data collection, to analysis and interpretation, solution implementation and take-up. While exhibiting important differences in scope and focus, forms of participation and intended impact, all three approaches face similar challenges of motivating, enabling and structuring citizen engagement. They therefore explore various forms of collective intelligence that often require a lot of groundwork to be implemented (e.g., mobilising large numbers of participants) and can be overwhelming for a single project. A growing number of platforms aim at supporting citizen engagement in DSI by facilitating various forms of collective intelligence (for an overview see Bria et al. 2015).

Purposes and typologies of citizen engagement

Citizen involvement in social innovation is often valuable in its own right because it makes the development of solutions to societal problems more transparent to the people affected by them. There are also other common reasons for citizen engagement: citizens bring local knowledge about the problem and their needs; they can generate new solutions informed by their knowledge; and they bring different points of view, leading to more diverse perspectives on the problem (Davies et al. 2012a). When involved in the process, citizens are also more likely to accept the solutions. This is especially important to the many types of societal problems that inherently require citizens to change their actions or behaviour (e.g., public health, sustainable consumption) (Davies et al. 2012a; see also Schroer et al. in this volume). The benefit of this is emphasised by DSI that not only uses digital technologies as innovation enablers, but also makes the engagement of citizens in the creation of solutions a normative prescription (Bria et al. 2015). Many of these issues also echo the motivations for citizen engagement in citizen science (see Bonney et al., 'Public Participation', 2009). They are especially reflected in participatory approaches that involve citizens as equal partners with scientists, and that value different types of (non-scientific) knowledge from local, often marginalised, communities (Haklay 2013; Stevens et al. 2014).

Devising a DSI or a participatory citizen science project requires choosing appropriate forms of citizen engagement for the given purpose. Different typologies of engagement from both fields can inform such decisions (see table 9.1). With respect to the level of citizen influence on the project, Bonney et al., 'Public Participation', 2009, differentiate between projects where citizens collect and contribute data (contributory projects),

Box 9.1. Example of a digital social innovation project involving citizens as co-creators contributing local knowledge

Hybrid LetterBox

Hybrid LetterBox is an example of a project involving citizens as equal partners working with researchers in the development of novel solutions for local needs[1]. The project aimed at easing citizen participation in online discourses by connecting digital and the analogue channels of interaction. The Hybrid LetterBox is an 'augmented mailbox where anyone can throw a physical postcard that is automatically digitized, and uploaded to an internet platform to be spread and discussed' (Becker et al. 2015, 78). In developing the concept and prototype of the Hybrid LetterBox, the researchers initially collaborated with a group of elderly citizens, empowering them as co-designers. As the lead researchers Andreas Unteidig and Florian Sametinger describe in their project report, this helped them to discover new target groups, to better understand potential uses and to arrive at the final design of the original concept:

> The idea for the prototype emerged out of co-design workshops, since some of the predominantly elderly inhabitants

(continued)

of the neighborhood we worked with do not have access to digital media. This presented itself as a problem, since we were working on a local social network and particularly aimed at involving those who have not been active in the shaping of their neighborhood so far. We realized that we needed an interface that connects the digital and the analog world, and hence started working on the development of the early prototype together. [. . .] In the course of running the first tests and experiments with an early prototype in this neighborhood, many different groups – children, families, senior citizens – started using our technology in a broad range of ways: they formulated questions, ideas, they scribbled or contributed their thoughts in their respective mother tongue. It became clear that our target group is much bigger than we initially anticipated and that it proves useful in a variety of different contexts. Participating in discourses through the usage of our artifact proved attractive, also to those who are digitally well connected. (Becker et al. 2015, 84 and 88; see also Herlo et al. 2015).

Source: http://www.design-research-lab.org/projects/hybrid-letter-box/

Fig. 9.1 Hybrid LetterBox. (Source: Matthias Steffen)

Table 9.1 Overview of typologies of citizen engagement

Design factor	Typology of engagement	Source
Control level	• Contributory, collaborative, co-created citizen science projects	Bonney et al., 'Public Participation', 2009
Cognitive complexity and type of contribution	• Crowdsourcing, distributed intelligence, participatory science, extreme citizen science	Haklay 2013
Type of contributed knowledge	• Information about present needs (understanding individual problems and needs, understanding larger patterns and trends) • Developing future solutions (co-developing or crowdsourcing solutions)	Davies et al. 2012a
Function	• Provision of information and resources • Problem-solving • Taking and influencing decisions	Davies et al. 2012b
Scale	• Small-scale vs. large-scale engagement	Davies et al. 2012a

projects where citizens help with the data analysis and may contribute to refining the project design (collaborative projects) and projects in which citizens co-design the project together with scientists, and are involved in all stages of knowledge creation (co-created projects) (see also Ballard, Phillips & Robinson in this volume). This framework can also be read as a map of different types of activities that are compatible with the chosen level of control over the knowledge creation process (see Bonney et al., 'Public Participation', 2009 for a detailed analysis). The typology proposed in Haklay (2013) can be read with respect to the level of cognitive engagement and type of contribution. Crowdsourcing resources (e.g., citizen sensors) are the 'simplest' form of participation, with little cognitive engagement and no citizen influence on the project design. Involving citizens in activities such as data collection and annotation is a way of harnessing their distributed intelligence ('citizens as interpreters'), whereas enabling them to contribute to the problem definition and data analysis leads to participatory science projects. In ‘extreme citizen science’, citizens are empowered to collaborate with professional scientists on many core aspects of designing the scientific project – from problem choice to the interpretation of results – and on ensuring the relevance to their local context. This modality also opens ‘the possibility of citizen science without professional scientists, in which the whole process is carried out by the participants to achieve a specific goal’ (Haklay 2013, 12). This matches DIY science and DSI, where citizens act as active co-creators and initiators of solutions to problems relevant to their social realities (see also Smallman et al. in this volume on Responsible Research and Innovation).

With respect to the type of knowledge generated, a social innovation project will typically involve citizens in gathering information about present needs and/or to participate in the development of future solutions (Davies et al. 2012a). This is often performed with ethnographic techniques, workshops or consultations for eliciting citizen knowledge of the problem, competitions for novel solution ideas, various testing and rating techniques for evaluating the suitability of different solution ideas or assessing the importance of different problem aspects. Co-developing new solutions in smaller groups is often performed through hands-on workshops and bootcamps involving citizens, scientists, technology and domain experts, while crowdsourcing is applied to extend the ideation process to (very) large groups of participants. From another functional perspective, citizens can help in the provision of information and resources (e.g., crowdsourcing data or donations), support problem-solving (e.g., competitions, co-design) or be involved in taking and influencing decisions (e.g., campaigning or participatory planning) (Davies et al. 2012b).

Methods and critical issues

Despite a large body of experience, citizen engagement remains a challenge, especially when it comes to harnessing more complex forms of citizen collaboration that go beyond data collection (Rotman et al. 2012). Digital social innovation and participatory citizen science projects have been exploring this challenge, but there is also a long tradition of precursors that provides helpful insights (see also Haklay; Mahr et al., both in this volume). Citizen engagement in knowledge brokering and co-designing is closely linked to the concepts of user-centred and participatory design, which both place the elicitation of user needs, feedback and ideas at the core of the solution design process (see also Gold & Ochu in this volume). While in user-centred design, the project design is defined by professionals (e.g., designers, technology experts), participatory design gives major influence to the users and stakeholders. It considers them as equal partners to the professional actors and makes co-creation activities a key element. Citizens as 'users' and stakeholders impacted by the problem and the solution being developed are involved through a range of methods, from needs and requirements workshops to focus groups and ethnographic studies to storytelling (see also Hecker et al. 'Stories' in this volume) and storyboarding (see box 2), games and co-operative prototyping, and to empowering lead users to experiment with, and adapt, solution prototypes in real-world settings (for an overview see Müller 2002). Such focus on joint learning and co-creation is closely related to co-created citizen science projects and to extreme citizen science. Similarly, the request for scientists to acknowledge and engage with the relationship of their work to a given social reality (Haklay 2013) resonates with the core ideas of participatory design.

A key issue for effective knowledge brokering and solution co-design is the creation of a shared understanding between the different worlds of citizens – their levels of knowledge and their lived reality – on the one hand, and those of professional scientists, domain and technology experts on the other. Methods such as concept visualisation, mock-ups, storytelling and prototyping can support this. Enabling effective joint exploration of the problem space and possible solutions includes the need to bridge information asymmetries and goal conflicts between different stakeholders (e.g., citizen volunteers, scientists, policymakers). This is frequently addressed through face-to-face interaction in physically co-located settings to further a sense of transparency and trust building. Supporting collaboration in such settings can benefit from adapting existing techniques and designing new tools for reducing information asymmetries, increasing transparency and reducing cognitive complexity, for example, through shared visualisations of multiple perspectives representing the views of different stakeholders (Novak 2009).

All such approaches come with a price: they require intensive engagement with participants and face-to-face interactions, often embedded in their day-to-day environments and across prolonged periods of time. Many studies have highlighted that participants are motivated by a wide range of factors, from identification with a project focus and goals to personal interest (e.g., learning new things), desire to help (e.g., helping science or society), shared values and beliefs (e.g., knowledge should be free), social recognition and reputation or simply fun and enjoyment (see for example Rotman et al. 2012; Raddick et al. 2013; Nov et al. 2011b;

Geoghegan et al. 2016). Recognition and regular feedback are key elements to ensuring continuing engagement and catering to changes in motivation (Rotman et al. 2012; Geoghegan et al. 2016). Regular social interaction (with scientists and other volunteers) is important (Geoghegan et al. 2016) but requires effort (e.g., regular face-to-face meetings and group activities). Even if locational constraints can be bridged by online interactions and mechanisms (e.g., crowdsourcing, continuous online feedback), online participation tends not to be fully representative. A few community members typically provide the majority of contributions, while others are 'passive' consumers, with a small portion of occasionally active participants (the 90-9-1 rule [Nielsen 2006]). Participation also tends to vary with time, requiring regular triggers of attention and dedicated community moderators to maintain activity dynamics over extended time spans.

Citizen engagement in co-creation activities (which are typically complex and demanding) thus risks reaching only a small portion of society. Engagement levels frequently change over time so activities with limited participants also risk failing to recruit new participants as existing ones become inactive. In fact, the transition of participants' roles (e.g., from passive to active) are an important mechanism of online participation (Preece & Shneiderman 2009). Successful community platforms tend to offer a range of different participation options requiring varying levels of

Box 9.2. Storyboards are often used in user-centred design to facilitate involvement of target users and stakeholders

Storyboards as a co-design technique

User-centred design techniques readily lend themselves to facilitating user involvement in co-creation and co-design processes for participatory citizen science or social digital innovation. Visual storyboards are an example of a technique commonly applied in system design practice. They are used to illustrate initial ideas about possible solutions and the ways they would be used in practice, in order to facilitate discussion about the actual problem, proposed solutions and new ideas with intended users and stakeholders. Below is an example from a project developing a platform for citizen engagement in water saving and sustainable water consumption (Micheel et al. 2014).

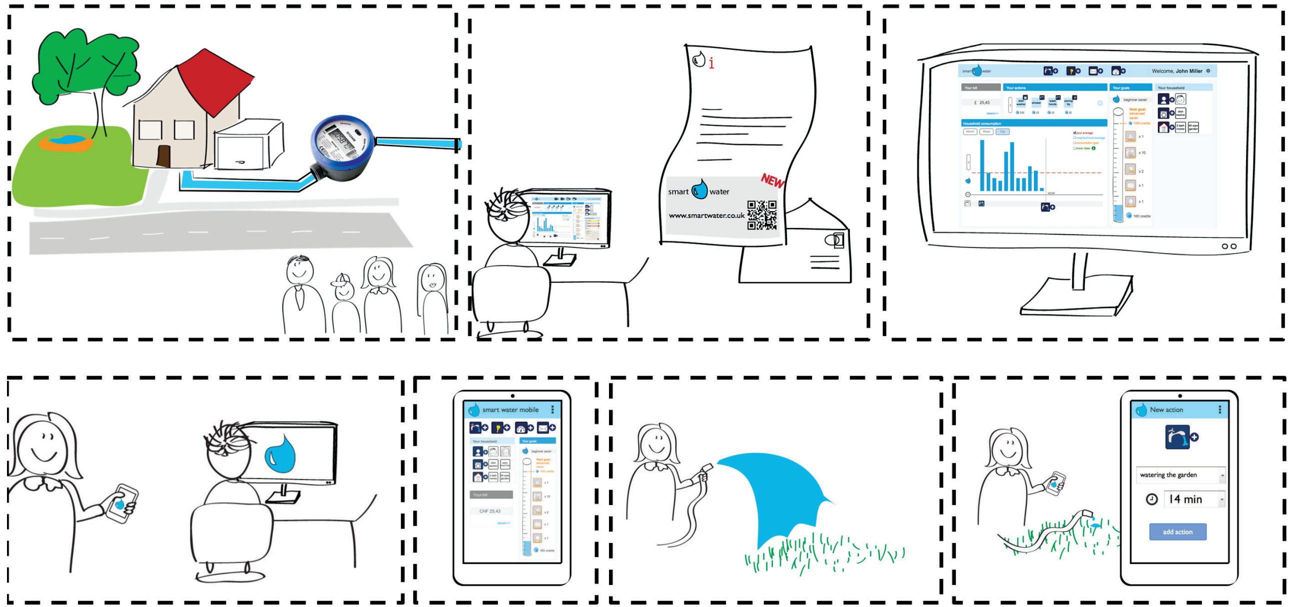

Fig. 9.2 Example storyboard as user-centred design technique

effort, allowing transition across different roles, based on participant's motivation, capabilities and situation through time (Anderson et al. 2012). A successful participation model will thus include simpler activities, with little complexity and cognitive effort (e.g., data collection) together with more complex activities, requiring more effort and/or more regular engagement (e.g., data analysis, solution co-design, evaluation and interpretation of results) (see Kieslinger at al. in this volume for more on evaluation). Face-to-face workshops or co-design sessions will be combined with online interaction and different options for the contribution of different types of knowledge, with some requiring more, others allowing less continuity of participation. Social recognition and reputation gained through regular feedback from the project can be combined with motivational designs using game-like elements to reward and make visible personal activity and achievements (Bowser et al. 2013; Iacovides et al. 2013). Joint exploration of the problem and solution space and co-creation of new knowledge will be facilitated by applying existing or developing new tools for alleviating information asymmetries between citizen volunteers and professional actors.

Online platforms

Effectively implementing such diverse and flexible models of citizen engagement is far from trivial. Beyond the issues identified above, other challenges concern the practicalities of implementation, such as choosing an appropriate engagement method for a given purpose, reaching the target groups and potential participants, disseminating the results of co-creation activities and supporting the uptake of outcomes and solutions. To facilitate this, (online) platforms designed for different types of citizen engagement and different forms of collective intelligence have been established (see Bria et al. 2015; Brenton in this volume). This section presents two cases studies: the CHEST platform for digital social innovation and the Open Seventeen citizen science challenge.

CHEST Enhanced Environment for Social Tasks

In the European project CHEST[2], citizens, social innovators, scientists, technology experts and other stakeholders collaborated in the participatory development of innovative solutions to societal challenges enabled by digital technologies. The CHEST online platform provided different tools and supporting measures including seed funding schemes, crowdsourcing

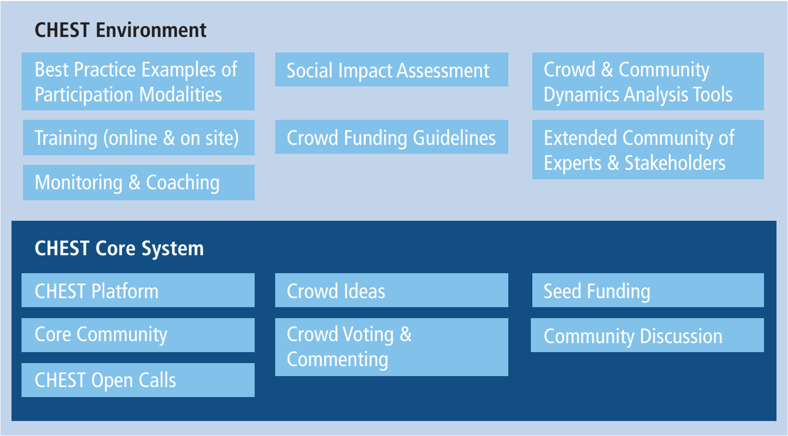

Fig. 9.3 Architecture of the CHEST Enhanced Environment for Social Tasks

tools, on-site/online coaching and training, and best practice guidelines for knowledge co-creation (figure 9.3). The project was carried out by three main partners, Engineering – Ingegneria Informatica SpA, European Institute for Participatory Media and PNO Consultants – extended by a network of 18 supporting partners and enlarged by 23 new partners through open calls (Chest 2016).

CHEST supported 35 ideas and 28 projects over three years, such as a platform exploring the use of Blockchains in product supply chains to foster transparency and sustainable consumption; a low-cost crowd-based traffic sensing device and analysis tool; a solution for self-monitoring and sharing of air pollution data; apps supporting people suffering from eating disorders or mental health; and many others. Such projects have actively involved 36,000 citizen participants in the different stages of the innovation process (table 9.2): They have provided knowledge (e.g., on social needs and solution ideas) and resources (e.g., placing traffic sensing devices in their homes), participated in problem-solving (e.g., analysing traffic and air pollution), co-designed solutions and influenced decision-making (e.g., voting on ideas to be funded, influencing local planning). Citizen engagement in different forms of collective intelligence has been facilitated at two main levels: several crowdsourcing schemes and instruments have been implemented at the platform level (e.g., crowd voting, commenting and monitoring), while coaching and training has been provided for the selection and implementation of appropriate citizen engagement methods at the individual project level.

Table 9.2 Overview of the main citizen engagement methods in the CHEST platform for digital social innovation

Stages of the social innovation process			
Problem identification and selection	Development of new solutions	Evaluation and monitoring	Uptake and scaling
Idea competition, crowd commenting, crowd voting	Crowd commenting, user-centred and participatory design	User-centred evaluation, crowd monitoring	CHEST extended community and crowd

Problem identification, idea generation and selection

The bottom-up selection of societal problems and the generation of solution ideas has been supported through three competitions with monetary rewards: (1) call for ideas outlining a solution to an important societal problem requiring further exploration (e.g., of technical feasibility or potential social impact), with 35 proposals awarded €6,000 each; (2) call for projects developing an initial idea into a product or service ready for deployment, with five winners awarded up to €150,000 each; and (3) call for prototypes turning a solution into a functional prototype evaluated with target users, with 23 winners awarded up to €60,000 each (see Ficano 2014).

The call for ideas implemented an open innovation design where all the submitted proposals were publicly visible and could be commented on by a crowd of volunteers (e.g., critique, improvements). The submitters responded to comments and engaged in collaborative idea refinement. The submitted ideas were also voted upon by the public (after a registration process) and the submissions with the highest number of votes were selected as winners. The recruitment of the crowd of volunteers was supported by a Europe-wide dissemination campaign, resulting in nearly 5,000 registered crowd members. The call for projects and the call for prototypes also implemented a competition design, but the selection of proposals was performed by an expert jury (including researchers, technology experts, social innovation experts, civil society, public institutions and media representatives).

The call for ideas generated 1,141 comments by 956 participants (19 per cent of total crowd) and 28,851 votes by 4,886 participants (98 per cent of total crowd) over 21 weeks. This is a high engagement rate compared to much lower rates of typical online community participation (1–10 per cent active users), suggesting that the voting worked as a low-effort

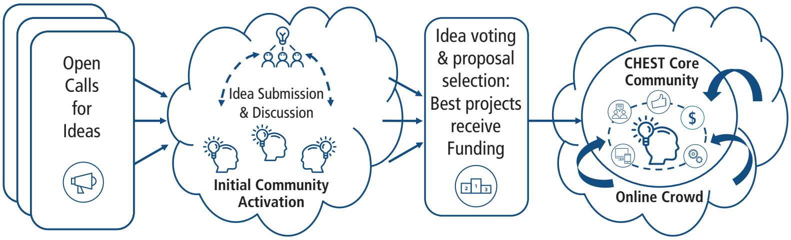

Fig. 9.4 CHEST bottom-up problem selection and solution generation process

activity motivating engagement. A visual network analysis performed on the voting and commenting activity has shown that many users commented on and endorsed different ideas, rather than supporting only one idea for which they may have been mobilised by the entrants (see Becker et al. 2015).

Project implementation

All 28 projects applied different methods for citizen engagement in knowledge brokerage (e.g., providing information and knowledge about the specific societal problem and citizen needs), resource provision and co-creation (e.g., co-designing solutions, co-analysing data, testing prototypes). This was facilitated through group and individual coaching (on-site, online, email) and training materials. The vast majority of the projects (79 per cent) involved citizens in the main co-design process: from the identification of the specific needs and requirements for a given problem, through co-developing solution ideas to evaluating the suitability of the developed solution concepts and prototypes. Only a smaller number of projects also involved citizens in the (re)definition of the problem to be addressed (18 per cent) (table 9.3).

Engagement methods used by most projects included on-site workshops (93 per cent, see for example figure 9.6), traditional interviews (71 per cent) and surveys (64 per cent). More "sophisticated" methods, such as lead user involvement in experimenting with the prototypes (figure 9.7), piloting (i.e., testing prototype solutions in prolonged real-world usage) and continuous online feedback were also used, though to a lesser extent (14 per cent, 21 per cent and 39 per cent respectively, see figure 9.5). The most popular were combinations such as on-site workshops with interviews (seven projects), surveys with on-site workshops and online continuous feedback (three projects) and surveys with on-site

Table 9.3 Citizen involvement in individual project phases

Project level citizen engagement in CHEST	
Citizens involved	31.047
Target groups*	79
Project phase	No. of projects
Problem (re)definition	5 (18 per cent)
User needs & requirements	25 (89 per cent)
Solution design and implementation	24 (86 per cent)
Test/Evaluation	28 (100 per cent)

* The target groups varied from project to project (depending on their specific goals) and ranged from children, youth and schools to elderly people, people with eating disorders, refugees, citizens in general and many others.

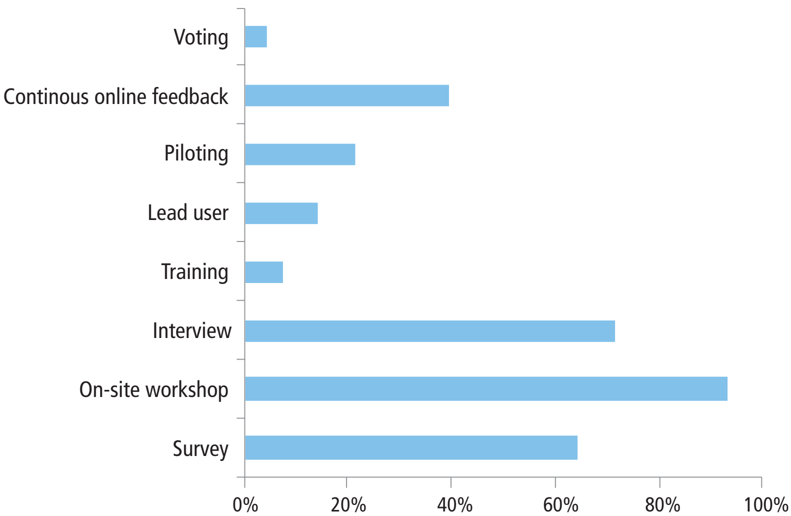

Fig. 9.5 Citizen engagement methods applied by CHEST-supported projects

workshops, interviews and online continuous feedback (three projects). Due to the small sample, no statistical correlations between the used method mix and the project evaluation rating (see next section on assessment process) could be established. However, it sticks out that the top three rated projects regarding the suitability of developed solution used a method mix of three or more methods. Moreover, the project with highest

Fig. 9.6 Co-design workshop in the TransforMap project. (Source: transformap.co)

Fig. 9.7 End-user test session in Project99/AyeMind. (Source: We Are Snook Ltd)

evaluation (4.94 on a 1–5 scale; see box 9.1) used the second highest number of methods of user engagement (5 methods), including lead user involvement and piloting.

A combination of offline and online activities in implementing the above methods was the most effective engagement strategy by the number of participants and the diversity of target groups, as well as in the number of tools developed to alleviate information asymmetries (table 9.4).

Box 9.3. Lead user and piloting methods in the Magenta TrafficFlow project

Magenta Traffic Flow

This CHEST-supported project for participatory traffic monitoring and management implemented a Living Lab approach in Florence (Italy) to co-design its solution. Starting from day one it involved a small group of initial users to gather feedback, assess and setup the technology developed in the project. Existing grassroots communities (e.g., Ninux, Fab Lab) were also involved in the co-design processes through on-site workshops and online feedback.

Fig. 9.8 Sensor for traffic monitoring

Participants set up the privacy-preserving traffic monitoring points in their homes and tested the sensor and tool in real-world use. They provided input regarding sensor requirements, privacy and the design of the analysis tool. The sensors collected more than 50 million data points, classified in terms of their location, size of the vehicle, speed and type. All data has been made available in the open data portal of Florence and has been used in participatory traffic planning sessions.

Source: http://www.magentalab.it/

Table 9.4 Strategies of implementing methods of citizen involvement in CHEST

	Projects	Target groups	Citizens involved	Info. asymmetry tools
Offline involvement	12	38	277	53
Online involvement	2	6	110	19
Offline and online	14	61	31,000	203

Monitoring and project evaluation

CHEST also used a crowdsourcing model to collect citizen feedback on project progress and success, throughout the project cycle. The results of citizen assessment were provided as a feedback to the projects (and were not visible publicly), rather than as control instance for the funders. This allowed projects to assess their progress and take corrective actions. Using the CrowdMonitor tool developed for this, citizens assessed projects by rating them on a 5-point Likert scale with respect to three main aspects: the solution approach ('The project implements an appropriate solution to the addressed social problem'), the project progress ('The project is likely to reach its goals'), and the regularity of project updates ('The project informs regularly about its progress'). The CrowdMonitor has been available for 6.5 months during which a total of 521 different users made 580 assessments of the 28 projects funded by CHEST, totalling 1,738 responses to individual questions[3]. Most assessments were positive or very positive (82 per cent) with a minority of undecided (13 per cent) and a small portion of negative votes (5 per cent). Most negative and undecided votes related to the regularity with which the projects informed about their progress.

Such rating patterns suggest that the crowd assessments can be considered credible, though probably skewed by votes from avid project supporters. The use of CrowdMonitor for continuous feedback rather than a final verdict of a project's success is likely to have contributed to more realistic feedback. This is supported by the assessment of projects based on predefined social impact key performance indicators (KPIs) by the CHEST consortium, which were even more positive than the crowd results.

While the crowdsourcing model worked well in this case due to the voluntary engagement of participants (based on interest in the topic and/or results of a given project), and low-effort feedback on project progress, critical issues can arise, ranging from the relationship between participant motivations and the quality of contributions, to ethical concerns such as the relationship between benefits accruing to participants and those accruing to the project leaders. These critical issues in different models of crowdsourcing and citizen science have received increasing attention and should be carefully considered when applying crowdsourcing methods (see e.g., Harris & Srinivasan 2012; Gilbert 2015; Resnik, Elliot & Miller 2015; Bowser et al. 2017).

Citizen Cyberlab and the Open Seventeen Challenge

At Citizen Cyberlab (CCL)[4], researchers from different backgrounds experiment with new forms of public participation in research, encouraging citizens and scientists to collaborate in new ways to solve major challenges. The lab is a partnership between the European Particle Physics Laboratory (CERN), the UN Institute for Training and Research (UNITAR) and the University of Geneva. In September 2015, the United Nations adopted Agenda 2030, which includes a set of 17 Sustainable Development Goals (SDGs) that aim to end extreme poverty, fight inequality and injustice, and tackle climate change over the next 15 years. The Open Seventeen Challenge[5], launched by the Citizen Cyberlab in 2015, is based on the understanding that some of the datasets best able to monitor progress towards the SDGs are local in nature, and can thus be better generated and collected by individuals and organisations representing civil society. The Open Seventeen Challenge involves three other partners: GovLab (the Governance Lab at New York University)[6], the advocacy group ONE Campaign[7], engaged in actions to end extreme poverty and preventable diseases, and SciFabric[8], which develops open source crowdsourcing tools.

Approach

In traditional citizen science, the involvement of professional scientists helps to address issues of data quality due to wide variability in the skills and expertise of participants. However, modern technology means that even those without research experience can in theory set up a participatory initiative using open source hardware sensors and software platforms that automate statistical validation procedures. This is particularly true for social and civic projects in which participants are asked to collect data or contribute to data analysis.

The Open Seventeen Challenge provides step-by-step coaching in the design and implementation of crowdsourcing projects led by non-professionals to increase their chances of success and impact. This includes both technological and social aspects. The Challenge recurs every six months, and involves the following elements:

- A project pitching phase: Candidates identify open data relevant to an SDG (e.g., photos, scanned documents, video clips, tweets), define a crowdsourcing project with clear, measurable outcomes, and then submit their idea. A maximum of 10 projects judged viable, or having a good potential of becoming so, are selected.
- Online coaching sessions: Sessions use a web conference platform and specifically designed online tools for project development. Over three months, the partner organisations help refine the project concept, including how to use crowdsourcing and ensure data quality with CCL, and how to optimise social impact at the community and policy levels with GovLab.
- Technical implementation and promotion: The projects set up a prototype crowdsourcing app on an open source platform, web or mobile, with the help of SciFabric[9] and are then promoted through their networks and at international events, benefiting in particular from the ONE Campaign's[8] strong international following and social media savvy to raise awareness.

Results and challenges

In 18 months, the Open Seventeen Challenge has issued three calls and coached more than 25 projects in diverse areas. From the first two calls, partners coached 10 projects, including crowdsourcing for a street guide to sustainable businesses, a platform to facilitate access to generic medicines for specific diseases in Latin America, projects to crowdmap sexual violence in India, tracking water policies in Nigeria, mapping the resources in a mega-slum of Mexico City, and other initiatives enabling SDG monitoring led by civil society.

In the most recent call, the Open Seventeen Challenge invited citizens to tackle specifically SDG 11, which is about making cities inclusive, safe, resilient and sustainable. The projects participating in the ongoing coaching sessions include mapping food markets in cities; sampling and monitoring air quality in Santiago, Chile, and Geneva, Switzerland, with wearable open source air detectors; and monitoring the international reconstruction work in Gaza.

While traditional sources of official data remain important, such data can also be expensive to generate and leave large data gaps in areas where traditional data gathering methods are not applicable. The next

Box 9.4. Using the crowd to map rural services in Crowd2Map Tanzania

Crowd2Map Tanzania

In this project, a teacher reached out wanting to map rural Tanzania. Through Open Seventeen, she learned about the open source application Epicollect (http://www.epicollect.net/). With contacts from the partners' networks and the help of the crowd, Crowd2Map Tanzania was set up. The project has already mapped hundreds of services in Tanzanian villages and hosted an international mapping day. Data are now open and publicly available on OpenStreetMap.

step for the Open Seventeen Challenge will be to connect the grassroots initiatives to official government data producers and inter-governmental institutions, to ensure that crowdsourcing of open data by the public becomes a valuable resource in achieving the SDGs. As the executive director of UNITAR, Nikhil Seth, recently stated in a co-signed correspondence piece in *Nature*, 'governments will need to support projects that promote public participation in measuring progress towards the SDGs. National statistics offices must develop best practices for integrating crowdsourced data' (Flückiger & Seth 2016, 448).

Conclusions

Digital social innovation and participatory citizen science share the goal of engaging citizens with scientists and other professional actors in the collaborative development of different types of scientific, professional and practical knowledge, related to social needs. Ideally, individual citizens and local communities collaborate in the entire process of scientific, exploratory or creative inquiry: from the problem definition, through data collection, to analysis and interpretation, solution implementation and take-up. Successfully realising such types of engagement requires supporting different types of motivations and participatory activities, and appropriate methods for different purposes and project stages. In addition to existing experiences in the fields of citizen science and DSI, the methods and lessons from user-centred and participatory design provide actionable insights into how this might be successfully achieved.

Online platforms for collective intelligence can facilitate practical implementation by providing an initial community, access to crowdsourcing resources and (particularly important) coaching and monitoring support. Lessons from literature and case studies discussed in this chapter suggest that successful platforms will offer a range of different participation modalities with varying levels of effort, allowing citizens to switch between different types of engagement based on their motivation, capabilities, needs and resources. This should include both simpler activities, requiring little effort and little continuity, and more complex activities, requiring more effort and/or more regular engagement. Face-to-face workshops or co-design sessions can be effectively combined with online interaction such as continuous online feedback and well-known innovation methods such as lead user involvement and citizen experimentation in real-world piloting. Incorporating regular feedback to the participants and different mechanisms of social recognition are important for supporting the continuity of engagement. Coaching, training and monitoring support (online and offline) are essential enablers, but are resource and effort intensive. Crowdsourced approaches can provide one part of the solution (e.g., for continuous project feedback and monitoring). Other possible solutions could include better support for peer-exchange between different projects, recruitment of scientists and other professionals as volunteer mentors, or a community-driven massive open online course (MOOC) on designing and implementing DSI and participatory citizen science projects.

Notes

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2 The Collective Enhanced Environment for Social Tasks (CHEST) project was partially funded by the European Commission (grant agreement No. FP7-ICT-611333, http://chest-project.eu) within the Collective Awareness Platforms for Social Innovation and Sustainability (CAPS) programme: https://ec.europa.eu/digital-single-market/en/collective-awareness.
3 A few users did not reply to all three questions.
4 http://citizencyberlab.org/
5 http://openseventeen.org/
6 http://www.thegovlab.org/
7 https://www.one.org
8 https://scifabric.com/