Reflecting on deepening participation in recruitment and evaluation in citizen science - lessons from the WeCount project

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Abstract:
This paper focuses on an urban mobility citizen science project in which citizens participated in several ways, from technical development to engagement and evaluation. Drawing on asset-based community development, the WeCount project aimed to empower citizens to take a leading role in the production of data, evidence, and knowledge around mobility in their neighbourhoods. WeCount engaged with thousands of citizens in five European case studies, who were involved in co-designing the data platform, collecting/analysing the data, and lobbying for change. In WeCount, each participant mounted a low-cost, automated, road traffic counting sensor (a Telraam) to a window in their house that faced a road. The Telraam sensor counts the number and speed of cars, large vehicles, cyclists, and pedestrians. Given its efforts to distribute resources and share knowledge for bottom-up sustainable development, WeCount is representative of the shift towards greater participation and self-reflection in the design, delivery, and evaluation of citizen science. Future iterations of similar citizen science projects, as suggested by citizens, would benefit from more training in how to be an activist, more opportunities to get involved in each stage of the project and

more training on how to understand the data to ensure the future of urban transport and mobility puts citizens at the centre of decision-making.

Keywords: citizen science, evaluation, participatory, involvement

Introduction

Citizen science: a spectrum of involvement

Humans have always sought to understand and explain the world around them but the philosophy and practice of citizen science (by contrast with professional science) was not defined until the 1990s (Irwin, 1995; Bonney, 1996). Despite the twenty-five years since those first definitions, there still remain arguments over exactly what Citizen Science is. Unsurprisingly, since its formalisation as a concept in the 1990s (Strasser et al., 2019) its definition has remained ambiguous. Table 1 summarises a typology of the features of citizen science along two spectra: level of participation and ownership of knowledge and data. Given the differences of description, it's unsurprising that new concepts, such as community science, crowd science, and volunteer monitoring, have been introduced to attempt to define the phenomenon more clearly (Strasser et al., 2019).

Table 1 - Typology of features of citizen science projects, adapted from Bäckstrand, 2003; Conrad and Hilchey, 2011; Dibner et al., 2018; Haklay, 2013; Shirk et al., 2012; Cooper and Lewenstein, 2016.

	Contributory crowdsourcing	Distributed intelligence	Participatory science	Empowering, democratic approaches
Participation	Citizens as sensors (observers) and data providers, submitting data to an online platform.	Citizens as basic interpreters. Sometimes known as 'volunteered thinking', sharing information and responding quickly.	Citizens play an active role in decision making.	Collaborative science – problem definition, data collection/ monitoring, analysis and action. Can include the co-design of regulatory regimes together with marginalised communities.
Step of the scientific process	Data collection	Data analysis	Some or all	Every step
Knowledge distribution	Scientist-led. Data collector for scientists, with predefined questions or long-term monitoring goals for 'amateurs.	Citizen as data interpreter/ collaborator.	Community-scientist partnerships to document change through the collection of local and traditional ecological knowledge.	Citizen-led. Citizen as scientist, collecting and analysing data on community-generated questions with the assistance of professionals. Seen as lay knowledge holders.
Category	For the people	With the people	With the people	By the people

Examples	E.g., E-bird (NASEM, 2018), SETI (seti.org) and Smart Citizens (Capdevila and Zarlenga, 2015).	E.g., for conservation (e.g., iNaturalist), science broadly (e.g., Zooniverse) or for disaster risk reduction (e.g., Kankanamge et al., 2019).	E-participation (e.g., Pina et al. 2017) and adaptive governance e.g., ClairCity (Fogg-Rogers et al., 2020).	E.g., radiation post-Fukushima (Kenens et al., 2020), air quality (Griswold et al. 2020); or citizen-generated topics (Cohen et al., 2017).

However, if, as we do in this paper, one regards citizen science as a spectrum, one can locate a range of activities along it, depending on the level of citizens' involvement and the locus of knowledge. Along this spectrum, citizens could be involved in any or every step of research, from defining problems to developing projects, collecting data, working with technology, interpreting datasets, presenting findings, offering solutions/interventions, sharing results and evaluating processes – this is often called engaged research (Grand et al., 2015).

Until recently, most research involving citizen science used citizens as contributors (e.g., data gatherers) to researcher-led processes rather than as co-creators, and projects were researcher- rather than community-led (SCU, 2013). However, a recent political turn in citizen science, driven in part by the need to accelerate sustainability transitions, means that projects are moving from a "productivity view" to a "democratic view" centred on citizen empowerment and policy change for adaptive resource management and governance (Sauermann et al., 2020).

Engagement *with* citizens with the intent to develop co-created and co-produced citizen science, requires a shift of power away from scientific institutions and towards community partners and citizens. Using the example of the WeCount project, this paper will explore how citizen science projects can develop community participation in citizen science and how such projects can be collaboratively evaluated.

Citizen engagement in sustainability transitions

The need for citizen empowerment and policy change is well exemplified by citizen science projects focused on urban mobility, which seek democratic engagement to generate changes in behaviour. Citizens readily relate to issues around travel (Wibeck, 2014), such as the link between transport and emissions, while being less aware of the ways in which they can act not only to change their behaviour but also to influence policy. Therefore, mobility projects offer the opportunity to discuss climate change action and efforts towards reaching net zero carbon emissions.

Laggan et al. (2021) have documented the emergence of urban mobility citizen science projects that relinquish power to communities and support them to take action. Nevertheless, they note that most urban mobility citizen science projects remain focused on contributory participation. Behavioural and policy change requires an asset-based approach that can build on the strengths and potential of community members to bring about sustainable development (Kretzmann and McKnight, 1993). Asset-based community development – citizen-led, relationship-oriented, asset-based, place-based and inclusion-focused (Russel, 2021a) – has been shown to lead to effective, innovative and tailored solutions that better fulfil the needs

of diverse communities, from responses to the COVID-19 pandemic (Russel, 2021b) to wellbeing promotion in schools (Forrester et al., 2020) and resilience to climate change (Hossain and Rahman, 2021). However, evaluations of these projects, from citizens' experience, determinations of the extent to which power and resources have shifted into citizens' hands and the extent to which behaviour and policy have changed are either reported inconsistently or have not been published in peer review (Laggan et al., 2021).

Evaluating citizen science projects

Citizen science projects are evaluated for several reasons: to help justify the next proposal, to assess impact, to build an understanding of the strengths and weaknesses of and lessons learnt from earlier projects, and to help promote or advertise (Wehn et al., 2021). As evaluations tend to focus on just one or two reasons, this means only certain aspects of a project, such as audience reach, learning outcomes or environmental or policy impact, are evaluated and the evaluations of different aspects are rarely consolidated (Wehn et al., 2021).

Evaluation of citizen science projects has conventionally been conducted by in-house researchers or third-party organisations (Fawcett et al., 2003). However, reflecting the democratic turn of citizen science projects, citizens' involvement could likewise be extended into the evaluation process. Placing citizens at the centre of evaluation shifts how evaluators see their role. If evaluation is shared *with* and designed *with* citizens, everyone can better understand what works for citizens' involvement, what barriers (e.g., local customs or interests) might stand in the way, and what citizens need from other project stakeholders. For example, the 'Bristol Ageing Better' programme, a partnership of people and organisations working to reduce isolation and loneliness among older people in Bristol (UK), purposefully recruited older volunteers to evaluate the programme, built engagements in the programme on principles of asset-based community development, and trained community evaluators to assess impact and contribute to outputs and dissemination (Beardmore et al., 2022).

Fawcett et al. (2003, p21) outlined an interactive and iterative six-component framework for participatory evaluation: "(a) naming and framing the problem/goal to be addressed, (b) developing a logic model (or theory of practice) for how to achieve success, (c) identifying evaluation questions and appropriate methods (what do we want to know and how will we know it), (d) documenting the intervention and its effects (what are we doing, is it making a difference), (e) making sense of the data (what are we seeing, what does this mean), and (f) using the information to celebrate and make adjustments". This model of evaluation can be used to assess the degree to which citizen science projects are participatory and how participation can be further developed.

The WeCount project

This paper presents the case study of an urban mobility citizen science project that has involved citizens in more participatory ways, from technical development to citizen engagement and evaluation.

WeCount (*Citizens Observing Urban Transport*; 2019-2021) was a Horizon 2020-funded Science with and for Society citizen science project in five European case studies (Leuven in Belgium, Madrid/Barcelona in Spain, Ljubljana in Slovenia, Dublin in Ireland, and Cardiff in the UK). The project aimed to empower citizens to take a leading role in the production and

analysis of mobility data and to use the evidence for action on improved urban mobility in their neighbourhoods.

The project teams in each case study planned to recruit citizens and community organisations through face-to-face engagement, making targeted efforts to work with schools and with community groups, specifically groups engaging with people living in areas of low socio-economic status. However, COVID-19 restrictions prevented this from happening and citizens were instead recruited through traditional and social media. Recruitment involved using previous networks of contacts and relevant mailing lists, as well as advertising the project on Twitter and Facebook. Despite the pandemic, community organisations and local government relationships remained key to brokering connections with people living in areas of low socio-economic status. Participants interested in taking part in WeCount registered via an online platform and were asked to upload a photo taken from a window that faced a road. Photos were then assessed for suitability: having a clear view of the road with no trees or other obstacles that could interfere with the traffic sensor.

Participating citizens who lived in homes with a suitable road-facing window were given a Telraam, a low-cost traffic counter comprising a Raspberry Pi computer and a camera; this was developed by Transport and Mobility Leuven[1] before the project. The Telraam counts the number and speed of cars, large vehicles, cyclists and pedestrians passing the camera; it thus provides cheap and accurate data at a far greater temporal and spatial scale than is possible in classic traffic-counting campaigns. The data gathered by the Telraam were made freely available on a public platform[2] that allowed citizen scientists to access their own and their neighbours' data, which they could use as evidence to spark collective action and influence decision-makers. Citizens were involved in co-designing the data platform, collecting and analysing the data, and engaging with key stakeholders.

WeCount citizens took part, often as clusters of neighbours, in several workshops (held online due to the COVID-19 pandemic) to build connections, formulate problems, learn how to assemble the sensor, understand how to interpret and analyse the data, and share knowledge on how to advocate for policy and behaviour change. The engagement process (Figure 1) was piloted in two pilot case studies to allow citizens' questions and feedback to inform and influence the development of the sensor, workshops and events.

Figure 1 – The WeCount engagement framework and toolkit.

The WeCount evaluation

The evaluation methodology of WeCount comprised three parts: direct evaluation, monitoring, and self-reflection by staff (Sardo et al., 2021). Evaluation methods such as registration forms, feedback on workshops, online survey and interviews with citizens formed part of the direct evaluation; while monitoring relied on collecting number of attendees and demographic information for workshops, social media and website analytics and specific activity relating to the Telraam sensor (such as active counters, drop-out rates, etc.). Finally, the self-reflection part of the evaluation focused on the WeCount team, using tools such as reflective logs after workshops and events and in-depth interviews with staff (Figure 2 provides a detailed account of the evaluation methods used).

[1] https://www.tmleuven.be/en/
[2] www.telraam.net/en

It took an integrated approach, documenting direct (e.g., in workshops) and indirect (e.g., on social media) citizen engagement, citizens' experiences (e.g., time, enjoyment, knowledge improvement, technology development), and behaviour change (e.g., taking action with the data). The extent to which power and resources had shifted into community hands was also noted.

The evaluation of the WeCount project was detailed and in-depth but due to time and pandemic related constraints, it was not as participatory as it could have been. In WeCount, citizens have not contributed to the design and development of the evaluation framework, however they were active participants in elements of the evaluation process. Looking at the six-component framework for participatory evaluation by Fawcett et al. (2003, p21), participants took part in "(d) documenting the intervention and its effects (what are we doing, is it making a difference), (e) making sense of the data (what are we seeing, what does this mean), and (f) using the information to celebrate and make adjustments".

Figure 2 – The WeCount evaluation framework.

Direct evaluation and monitoring

Ethics Approval for the evaluation was granted by the UWE Bristol Faculty Research Ethics Committee (FET 20.02.034). Everyone taking part in the project and the evaluation received Participant Information Sheets and gave their informed consent to participate. Young people under 18 years consented to participate along with their parents' informed consent as well.

A variety of methods were used to evaluate the individual events and activities and the project overall. The evaluation methodology had to work across case studies and in different languages, collect high-quality evaluation data from events and activities, and from participating citizens and the project team.

The evaluation methods were selected based on *citizen personae* (idealised descriptions that help project designers understand users' needs, interests and desires (Nielsen, 2019)), those methods identified as appropriate to gather citizen feedback, anticipated return rates, and ease of use by project leaders in different cultures and with different existing evaluation expertise. The personae were drawn from the literature and developed by the project team, supported by an external expert. The *personae* were drawn from the literature and developed by the project team, supported by an external expert. *Personae* are used for design processes to develop products and tools that meets the users' needs and goals. The choice for using *personae* in the tool design process was based on the work by Long (2009), who claims that '*personae* strengthen the focus on the end user, their tasks, goals and motivation. *Personae* make the needs of the end-user more explicit and thereby can direct decision-making within design teams more towards those needs' (Long, 2009, p10). Since its inception in the 1990s, the persona-method has evolved from a method for developing IT systems to its use in many other contexts, including product development, marketing, communication planning and service design. Using the *citizen personae* approach the team set up several workshops, called TelraamLabs; these aimed at getting to know the citizens better, their motivations to take part and any needs in terms of support. The first TelraamLab led to identifying five personae, based on their different needs. Following TelraamLabs identified a need for a community platform, to foster networking and learning. Citizens worked together to identify and create

building blocks for a Community Platform. A final TelraamLab saw these building blocks discussed in detail, with a clear view of goals and content for each building block. The *citizen personae* was a positive approach which allowed the WeCount team to forge stronger relationships and better understand the needs, motivations and priorities of the participating citizens. It is a time-consuming approach, but one that provided important user-centered input with level of participation.

Cross-sectional mixed methods surveys were conducted in all five case studies, using an online survey tool (Qualtrics[3]). The survey was designed in English and translated into the local languages of each country[4]. Most questions were in closed format, as this is more inclusive for a variety of different participants (De Vaus, 2002). Open-ended questions, which allow participants to provide answers in their own terms (Grand and Sardo, 2017) were included but were kept to a minimum since they tend to have a lower response rate (Groves et al., 2004). The survey results were translated back to English, cleaned using Excel (2016) and analysed thematically with NVivo 12 before running descriptive and analytical statistical tests using SPSS 26. The online survey proved a successful tool to collect feedback from citizens across all case studies. The balance of open and closed questions enabled the participants to give quick and focused feedback.

Semi-structured interviews were conducted to directly access the observations, insights and experiences of the participants (Tong et al., 2007) in their own terms (Groves et al., 2004). The evaluation team offered training to WeCount staff to enable them to conduct interviews in their own language. Interviews were conducted online or as phone calls, transcribed verbatim and then translated into English if necessary. Conducting interviews with a small number of citizens in each case study made the task manageable for local teams. The in-depth data collected via interviews added richness and detail to the online survey data.

The WeCount staff, many of whom had no evaluation experience, later reflected on the evaluation activities and process, and their perceived success. The Evaluation Framework was praised for being very comprehensive, alongside a helpful evaluation mentor. Some staff members thought that the framework was too rigid, and that they would have benefitted from more training or face-to-face support (although they noted this was difficult due to COVID-19). The data from the staff reflections are not directly reported here but were triangulated to inform the citizen data analysis. The full results are included in the final project report (Sardo et al., 2021).

Results

Participant representation

WeCount engaged 1,988 citizens during the project. Levels of engagement varied, ranging from the high involvement of 368 ‘counting citizens’ who installed a Telraam sensor in their home (Barcelona/Madrid (n=50), Cardiff (n=70), Dublin (n=80), Leuven (n=86), and Ljubljana (n=82)), to the low involvement of citizens who simply received newsletters (n=163).

[3] https://www.qualtrics.com

[4] The final project evaluation report includes a copy of the survey: https://zenodo.org/record/6337258#.Yrl-TS8w1aY

There was an almost even split of male and female participants (51:49%). Many participating citizens were under 16 years old, due to efforts made to reach out to children living in areas of low socio-economic status. The age range of 'counting citizens' was broad, although the largest group (28%) was in the age range 35-49 years, which might be due to the technical nature of the sensor and the skills needed to set it up. Postcode data from Dublin and Cardiff indicates that 25% of the Telraams in those cities were distributed to people living in neighbourhoods of low socio-economic status, which is where higher levels of air, noise, and traffic pollution are usually observed (Barnes at al., 2019; Braubach and Fairburn, 2010) Neighbourhood data were not available for other cities. The educational level of counting citizens was exceptionally high; 81% of these participants held a first degree or higher. Furthermore, only 9% of participants reported their occupation as skilled manual, semi-skilled or unskilled.

The end-of-project evaluation survey was completed by 236 citizens; most (75%; N=178) were 'counting citizens', 18% (n=43) identified as 'involved' (e.g., took part in workshops/evaluations), and 3% (N=7) identified as 'local champions' who helped to recruit and support others. The demographic data for the survey respondents largely matched the overall data for all citizens who participated in the project, although they were skewed towards men (61%) and the highly educated (89% with a first degree or higher). In addition, 37 citizens responded to the request for interviews; 62% (n=23) identified as male and 38% (N=14) as female. All the interviewees were highly educated (holding a first degree or above). The modal age category (for those who gave their age) was 35-49 years.

Participation and co-creation

Thematic analysis (Braun and Clarke, 2006) of the citizen interviews was conducted; members of the project team independently reviewed the data to develop coding themes which were combined into six inductive themes for analysis. Two themes related to citizens' motivations for joining the project; citizens either identified as being 'Data Lovers' and were taking part for the technology and counting information or wanted the data to provide 'Traffic Evidence' which they would use in local campaigns. Two themes related to citizens' experiences of conducting citizen science on traffic data; 'Car-free Campaigning' discussed the various ways that citizens either were using, or hoped to use the data to evidence their car-free or speed reduction campaigns; 'Creating Community' discussed how the citizen science project had connected people locally through the workshops or campaigning, or in some cities during the COVID-19 pandemic, citizens felt they had missed out on community opportunities. Two final themes offered feedback on the 'Project Operation' and 'Using the Telraam', from the participants' experience of being citizen scientists. The qualitative interview data were triangulated with quantitative data from the survey and the datasets are presented in an integrated manner in this section.

Motivations for joining WeCount

The survey showed that although motivations for joining WeCount varied, the main motivations were having an interest in sustainable mobility (N=100; 22%), wanting to contribute to research (N=94; 21%), wanting to make a difference (N=89; 20%) and wanting to count traffic (N=81; 18%). An interest in science/citizen science or technology was less of a motivation for joining, which is understandable given that the project was promoted to, and thus attracted, citizens who wanted to make a difference to urban transport and mobility. Men

were significantly more likely than women to join WeCount because of an interest in technology[5].

There was a significant difference between higher educational attainment and science-related motivations[6]. In other words, highly educated people are more likely to suggest these are their motivations. There was no significant difference between age and motivation. A more participatory approach to the survey evaluation would likely have uncovered additional motivations, as the evaluators included what they assumed were the motivations to participate in WeCount.

Most of the citizen interviewees were motivated to join WeCount because they wanted to gather objective evidence about the traffic on their street. Many told stories about discussing levels of traffic, speed, noise and air pollution with policymakers, but being unable to prove them:

> *It's an additional motivation to have the data… They can't deny certain things anymore. That gives you a weapon in your hands – although that might be somewhat aggressive wording. An additional instrument, something you can use.* (LeuvenCitizen Interview04)

> *It is a busy road, there's no denying that, but it's actually busier than we thought… it's really revealing and hopefully, it can be building and used for some kind of constructive change, yes, that's what we're hoping.* (CardiffCitizen Interview07)

Motivations for remaining with WeCount

Among survey respondents, the most common reason for remaining with the project was that they liked 'being part of a research project' (N=144; 34%) (Figure 3), followed by feeling that they were 'making a difference' (N=80; 19%). Interestingly, 'technology' (which was ranked sixth for motivation to join) came third (N=75; 18%), which suggests that the experience of using the Telraam and associated tools and platforms during the project offered participants some added value. Gathering evidence to support a campaign (N=65; 15%) came fourth, which probably relates to respondents' existing interest in sustainable mobility; that is, they might already be active in this space and have been motivated to join to further their campaigning.

There is no statistical difference between age or educational attainment and favourite aspect, however there is for sex[7]. Women were statistically more likely than men to consider collective problem-solving to be their favourite aspect of WeCount, this indicates that women enjoyed working with others to come up with solutions for traffic issues in their local areas.

Figure 3 - Favourite aspect of WeCount.

[5] Perhaps rather unsurprisingly, there is a highly significant difference between gender and an original motivation in technology (Mann-Whitney U= 4150.5, n_1=n_2=236, P <.005 two-tailed)

[6] (Kruskal Wallis test): "to count traffic" (H (4) = 13.22; P = .01), "to contribute to research" (H (4) = 10.26; P = .03), and "an interest in science/citizen science" (H (4) = 10.26; P = .01)

[7] Kruskal Wallis testing found that working collectively to solve problems was highly significant between sexes (H (1) = 9.76; P = .003). *Post hoc* Mann Whitney testing found that the mean score for this favourite aspect is on average -.209 points lower for men than for women. This mean difference is significant at the 0.05 level (P = .013).

The interview data reinforce the survey data; most participants said that they had enjoyed being part of the project. They felt that the project had operated smoothly, with good communication between staff and citizens. Many described the data from the project as an excellent legacy:

> *My whole objective out of this is to quantify how bad the problem is so we can start to do something about it. One of my goals (...) is that I can start presenting the data and present it in a way that illustrates the scale of the problem but then also present it in a way that if we enact certain solutions that favour active travel, we can also reduce the traffic as well.* (DublinCitizen Interview06)

Taking on board citizens' feedback, these ideas were developed by the project into an advocacy and policy workshop which was co-developed with citizens and ran at the end of the project to support community building.

Project co-development

Drawing on asset-based community development and community organising principles, 843 WeCount citizens took part in 56 events and workshops across the five cities. The Leuven case was also a pilot study, so its data were used to inform and adapt the development of later workshops and events. There were nine co-design workshops, 21 kick-off sessions to introduce the project, set citizens up with sensors and ask them about local issues they wanted to tackle as a community, nine data analysis workshops, four Application Programming Interface (API) workshops (several technology-literate citizens helped develop the API codes) and 13 young people's events. Videos and how-to guides were also created to support citizens with installation, a process many found daunting at first.

Where possible, participants were asked to rate their experiences of the workshops, using rating scales graded from 0 (poor) to 5 (excellent). Across all the cases, the mean responses for the citizen ratings are below:

- enjoyed the workshops (4.5)
- felt their input was valued (4.6)
- felt capable of installing a Telraam after the relevant session (4.3)
- felt capable of understanding the Telraam data (4.6)
- felt their knowledge was generally strengthened (4.6)
- felt better able to act based on the data (4.4)
- believed their input would be used to influence urban transport and mobility (4.4)

Using *citizen personae* created through a co-design process in a "getting to know you" session with Telraam counters, the Leuven team set up workshops to facilitate networking, learning, and inspiration. In these workshops, citizens used cardboard boxes and craft materials to depict what should be in a Telraam community platform. These visual representations formed several of the building blocks that eventually made up the community platform, which was finalised in the third and final workshop (Figure 4).

Figure 4 - Building blocks of the WeCount platform.

The data analysis workshops were co-led by the project team and citizen 'community champions'. The community champions (citizens who were particularly engaged, for example, those who supported neighbours throughout their engagement with WeCount)

presented their data and discussed how they were using them to call for change in their area. Citizens tended to focus on traffic-related topics, such the impact of roadworks, speeding, traffic filters and high traffic volumes. Citizens were able to deep-dive into the data, looking at the influence of time of day, school holidays and lockdown restrictions on the figures. Using the data, citizens were able to model and visualise potential scenarios, pose questions that allowed them to understand how unsafe people might feel when using roads in certain areas, and debate possible solutions. For example, in Cardiff citizens compared the speed limit against the data they received to determine if vehicles were speeding or not (Figure 5) and were able to visualise the number and type of vehicles speeding (Figure 6).

Figure 5 – Visualisation created by Cardiff citizens.

Figure 6 - Visualisation created by Cardiff citizens.

The approach taken here is an example of real co-creation, putting the data in citizens hands and supporting them to analyse it and draw their own conclusions.

Some citizens talked about how they worked with data or presentations for their living and so were comfortable with campaigning for social change. This triangulates with the demographic data on highly educated participants, which the citizens themselves noted.

> *That's the thing I really enjoyed, but I have professional experience in presenting data and my background is in engineering as well, so I have training in that, but people might not. I think maybe providing support for people in how to present the data and the evidence, because obviously, you know yourself, the story you can tell with the data is the most important thing and how you present it to bring people along with us.* (DublinCitizen Interview 07)

Having identified a need from the citizens for more knowledge on advocacy the project team and citizens co-developed an advocacy and policy workshop, which ran at the end of the project. After these workshops, one citizen group set up a WhatsApp group and created a declaration that they presented in a unified voice to their local council, while another group co-designed a citizen engagement activity using analogue data displays, which inspired a group in another city to create a similar activity. Overall, 10% of the citizens surveyed took actions ranging from hacking the sensor, to applying for funding, to lobbying decision-makers for urban mobility improvements.

Many of the citizens have formed connections and have continued counting beyond the end of the project; 56% of the sensors are still in operation at the time of writing. In the citizen interviews, several people stated that they intend to continue their involvement with their community and their city councils:

> *I felt I belonged to a community that was contributing by providing additional value that serves to perform some type of analysis subsequently.* (MadridCitizen Interview6)

> *It's interesting to hear all these people's ideas. For us, it's very centred to Leuven, but then you can really see how people … This is a very interesting thing. You organise an evening meeting in Leuven. The weather was awful that time and still people make an effort to go there for*

> *a voluntarily project to exchange ideas with others. It was very nice to see that the things that were discussed there, were actually picked up and developed further.* (LeuvenCitizen Interview01)

When citizens stop counting, they are asked to complete an offboarding survey, including reasons to opt out. This form is only rarely filled in, we cannot give an informed overview of reasons for quitting. Informally, we know that some citizens only planned to use the sensor for the duration of the project and stopped when the project finished.

While the COVID-19 pandemic restricted in-person end of project wrap-up meetings and celebrations, all the citizens who took part were thanked, and their success stories captured in blogs and videos[8].

Discussion

Citizen science appeals largely to well-educated people with an interest in technology and research (Haklay, 2018). This was demonstrated in WeCount; its participants were mostly highly educated, middle-class professionals; just 25% of the sensors were deployed in neighbourhoods of low socio-economic status, although we cannot say for sure if the users themselves were from low socio-economic backgrounds. This skew might be due to the fact that the technology involved presented a barrier to entry for under-represented groups, as participants needed to have access to high-speed Internet and possess a degree of skill and confidence in handling technology (Barnes and Chatterton, 2017; Barnes, Chatterton and Longhurst, 2019; Dawson, 2014). In addition, the original/pre-pandemic recruitment strategy was heavily affected by pandemic-related restrictions, meaning limited access to citizens from low socio-economic status. Another factor to bear in mind is that the project itself was, by nature, excluding people: it was advertised as a citizen science project focused on sustainable mobility, therefore mostly appealing to people interested in these subjects.

Nevertheless, WeCount succeeded in several aspects of participation: citizens were able to name and frame a problem to be addressed or goal to be reached that was relevant to their lives, for example focusing on specific place-based issues (e.g. traffic near a school), and they came together to set up the sensors, analyse the data, reflect on ways to improve advocacy for behavioural and policy change, and feed in, via the survey and interviews, their experiences and thoughts on how to improve the sensor and the project. Based on this typology, WeCount can be considered as an empowering/democratic approach to citizen science (Table 1). Yet, two flaws in the design became apparent during the project which throw caution to this designation. First, as mentioned, the prevalence of well-educated individuals with specific interests in sustainable mobility. Second, while the project sought to empower citizens from the start, there were not opportunities for them to co-evaluate the project. Nor was it always possible for them to come up with issues to solve as a collective as some kick-off meetings had representation from people from all over the city (and sometimes beyond). This latter issue could be largely overcome with in-person workshops in the future held in specific community spaces, which were not possible due to the restrictions imposed by the pandemic.

To make the project more inclusive would require more time and energy to reach out to marginalised communities and nurture those relationships – and thus a longer project

[8] https://www.youtube.com/channel/UCgsAlkg7JIQd597Wy1C5q1A

timeframe. Citizen science projects are historically unrepresentative, but this needs to change if we are to address the intersectionality of sustainability challenges with ethnicity, gender, disability, and economic status. Thus, in addition to a longer timeframes future citizen science projects will need to consider training requirements and finding ways to financially recompense gatekeepers to, and members of, under-represented communities (Griswold et al., 2020; Dawson, 2014). The purposeful design of WeCount, centred around deep involvement through community building and training lent itself to a sense by both citizens and the project team that it increased their motivation and the likelihood for it being sustained after the project ended.

A more fully participatory and co-created evaluation process meanwhile, would require citizen involvement to be embedded from the start of the project (Fawcett et al., 2003) to support co-creation of evaluation questions and appropriate methods, rather than evaluation being led by professional evaluators or researchers. This might well require citizen evaluators to be trained in evaluation design and methods and paid for the time they spend on co-creation or evaluation (Griswold et al., 2020; Dawson, 2014). If data on citizens' aims, objectives and subsequent actions had been included in the WeCount evaluation, they might have enabled greater insights. From the involvement participants did have, our findings indicate that the deeper their involvement of participants in the evaluation, the more we learn about their experiences with involvement. Participants also feel more connected to the project and the process, when they are involved in co-creation. Despite this lacuna, the WeCount evaluation methodology was flexible, capable of adaptation for each case study and offered the project team (many of whom had no experience of evaluation) training in evaluation methods, which offers lessons in how similar training and flexible design could be extended to enhance co-creation and citizen participation in future evaluations. There is room to make the evaluation more co-created but, by involving and training WeCount staff members with a range of experience, lessons were learned that will enrich co-creation in future projects and evaluations.

Moreover, WeCount's engagement framework facilitated co-design and, despite the lack of official community evaluators, the evaluation framework was able to draw on citizens' input in defining personae, shaping the technology, framing engagement processes and sharing lived experiences. Further steps could be taken in the future to make similar project evaluations more participatory and in line with Fawcett's framework (Fawcett et al., 2003). Drawing on our experience in WeCount, we argue that citizens could be involved in the evaluation from the onset of the project and, as they are recruited, asked to identify evaluation goals, how success can be measured and collaboratively choose methods and design evaluation questions. This process could initially start online, using interactive boards such as Padlet and progress to in-person discussions and focus groups.

Reflecting on participatory evaluation more generally, the use of participatory evaluation methodologies in citizen science has the potential to greatly contribute to impact assessment, as well as empower participants and build capacity. However, it is important to acknowledge that some projects may lack the capacity and resources to employ such methodologies (Nelson and Landman, 2020). Crishna (2007) argues that participatory evaluation is time consuming and requires skill-building for participants. This approach also tends to result in high volumes of data, another challenge to manage (Zukoski and Luluquisen, 2002). Therefore, participatory evaluation could lead to overburdening both the citizens and the project team.

Conclusion

Almost 2,000 citizens engaged in WeCount, over two years, including 368 who hosted a Telraam sensor. The largest group of citizens was aged 35-49 years, although a significant number was under 16 years old, due to the efforts to reach out to children living in areas of low socio-economic status. A quarter (25%) of the Telraams were installed in neighbourhoods of low socio-economic status. Citizens were highly educated, with 81% having at least a first degree, and many were either active campaigners on sustainable mobility or were interested in being part of a research project and making a difference.

While the citizen scientists did not frepresent the wider population of their country, they are a cohort of motivated people, who continue to count traffic and collect sensor data. Citizens' input to the design of the sensor and project workshops has resulted in a citizen science model for urban mobility that could be refined for deployment in other cultures and contexts. Citizens are looking to find ways to make their collective voice heard, such as using sensor data to apply for funding to meet their community's needs and challenges. Citizens are also displaying evaluation skills. However, citizen science projects would benefit from involving citizens in the evaluation process from the outset, for example identifying priorities and evaluation questions, as well as in developing a theory of change that would define the training and skills needed to support citizens in their evaluation journey. They would also benefit from financially compensating citizen evaluators and community champions who can amplify the voice of underrepresented groups. The next step is for citizen science projects to take on board these lessons, observing whether empowerment through not only knowledge and tools for collective action, but the finances to participate, leads to a more equitable seat at the decision-making table.

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