

# Community engagement around poor air quality in London: Citizen inquiry in a citizen science « Mapping for Change » project

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## Abstract

The Science in the City AQM (Air Quality Monitoring) project is dedicated to gathering and mapping data on air pollution. Citizens from various local communities across London play an active role in leading the design of research in their area, collecting and mapping data, interpreting and reporting the results. Their research was facilitated by Mapping for Change, an organisation that delivers mapping and sensing tools to empower local communities in improving their environment<sup>1</sup>. To gain a deeper understanding of citizens' experiences of AQM, we conducted 14 interviews with participants of these projects. Our analysis focuses on their motivations for taking part, and the informal learning that they experienced through participation in these projects. Our results show how the initial citizen inquiry, driven by local concerns on pollution levels that were subjectively experienced as high, lead to the implementation of a monitoring protocol of nitrogen dioxide (NO<sub>2</sub>) and particulates, which triggered rich, diverse and sometimes unexpected learnings among participants, depending on the activities concretely endorsed by the participants in the project. These learnings include: (a) on-topic knowledge (understanding of the distribution of pollution in time, space and height as well as of the main effects of pollution and factors affecting it), (b) increased awareness of the issues of air quality and political engagement, (c) increased community identity and empowerment, (d) increased skills in social media, communication, campaign coordination, management of monitoring tool, online mapping, and writing based on scientific data. Finally, we discuss the emergence, conditions and transformations of citizen inquiry throughout the project.

**Keywords:** participatory science, air quality monitoring, informal learning, creativity, community empowerment, environmental awareness

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<sup>1</sup> <http://mappingforchange.org.uk/>

## **Introduction**

Poor air quality is recognized as a massive health issue in Europe, especially in big cities. Medical evidence suggests that air pollution contributes to the global burden of respiratory and allergic diseases, including asthma, chronic obstructive pulmonary disease, pneumonia, and possibly tuberculosis (Laumbach & Kipen, 2012). Various long and short-term studies also conclude that there is a positive association between poor air quality and mortality rates (Rückerl et al., 2011). As it became evident from our data, some London (UK) residents are worried by poor air quality. To tackle this issue, a citizen science approach was adopted, which enabled local residents, many of whom had not been involved in a project of this kind before, to carry out grassroots data collection. Citizen Science – here, engaging citizens in research design, data collection, mapping and interpretation – is seen as a way both to get rich local data, and to increase awareness and learning in environmental issues. In this chapter, we will first introduce the Air Quality Monitoring (AQM) projects, especially in Barbican Estate, which was the largest community based longitudinal citizen science air quality monitoring project to be carried out in the UK. Following this, we will define the research questions driving our analysis of participation patterns in the AQM projects, and present our findings from interviews with volunteer participants. Finally, we will discuss the emergence, conditions and transformations of citizen inquiry throughout the projects.

### **1. Science in the City: Air Quality Monitoring project**

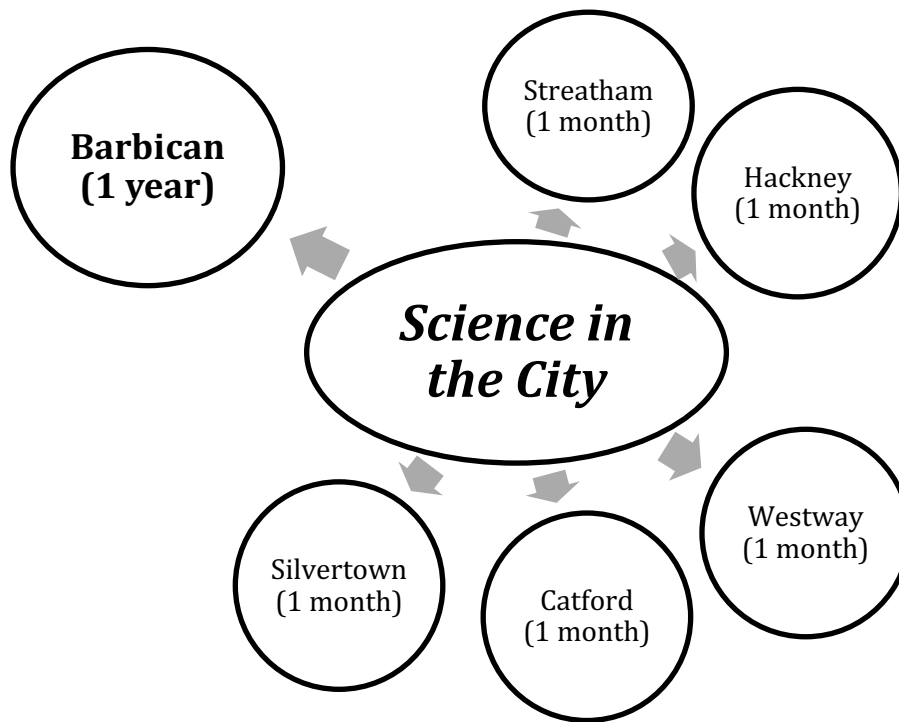
Science in the City, a project commissioned by the City of London Corporation and funded by Defra and the Mayor of London Air Quality Fund, was initiated with the aim to increase public understanding about air pollution, its causes, and effects, and how concentrations of different pollutants vary over space and time, in the City of London area. The project was coordinated by Mapping for Change, an organisation that delivers mapping and sensing tools to empower local communities in improving their environment. The project focused on two of the major ambient air pollutants, Nitrogen dioxide (NO<sub>2</sub>) and particulates, both of which are considered harmful to health.

Nitrogen dioxide (NO<sub>2</sub>) is one of the major air pollutants found in our cities and is largely attributed to the burning of fossil fuels (coal, natural gas and oil) and vehicle emissions. Industry and road transport are primary sources of these emissions across the UK. As an irritant gas, NO<sub>2</sub> can damage cell membranes and proteins. High concentrations can produce airway inflammation (experienced as a cough, chest tightness and difficulty breathing) and may lead to narrowing of lung airways, particularly among people with pre-existing asthma. Particulates constitute another significant contributor to poor air quality which vary considerably in their composition, size, and source. They are made up of organic and inorganic substances present in the atmosphere as both liquids and solids and are classified based on particle size. There are three classifications of particulates: PM<sub>10</sub> (particles less than 10 micrometres in diameter), PM<sub>2.5</sub> (particles less than 2.5 micrometres in diameter), and ultrafine (particles less than 100 nanometres in diameter). In urban areas the primary sources include diesel emissions, domestic solid fuel burning, construction activities and non-exhaust traffic emissions such as brake and tyre-wear. These particles are small enough to breathe in and can cause serious health problems, especially with the heart and lungs.

Science in the City started with an ambitious community-led study conducted over one year in the Barbican Estate, where citizens carried out an in-depth air quality monitoring project using both low and medium technical approaches. This was further extended to other shorter

projects (one month) that were initiated in other parts of London, such as Westway, Catford, Hackney, Streatham and Silvertown (see Figure 1).

**Figure 1. Science in the City**



The Barbican is a large residential estate within the busy « Square Mile » of the City of London. The Square Mile is known as a « pollution hotspot » and during periods of hot weather, health chiefs have advised the public to reduce their exposure to air pollution by choosing to travel on less-trafficked routes<sup>2</sup>. The City experiences some of the highest levels of air pollution in the country and recently it was reported that nearly 9,500 Londoners die each year from long-term exposure to nitrogen dioxide and fine particulates<sup>3</sup>. Informally it was known that a few Barbican residents had previously complained about air pollution to their local council, therefore it was viewed as an ideal starting point for the Science in the City project.

Mapping for Change started the Barbican project in October 2013. Residents were invited to attend a launch meeting at the Barbican Estate through various channels, including email, word of mouth, flyers and promotion by a local resident - a very active member of the community with a particular interest in air pollution. The meeting consisted of an introduction to the problem of air pollution in the City, current monitoring systems in place, the effects that poor air quality may have on health, measures currently in place to reduce air pollution and why this project was important. The meeting also included informal workshops to identify which areas the residents felt were the most polluted (hotspots) so these areas could be included in the monitoring programme. Residents were asked about what they felt could be

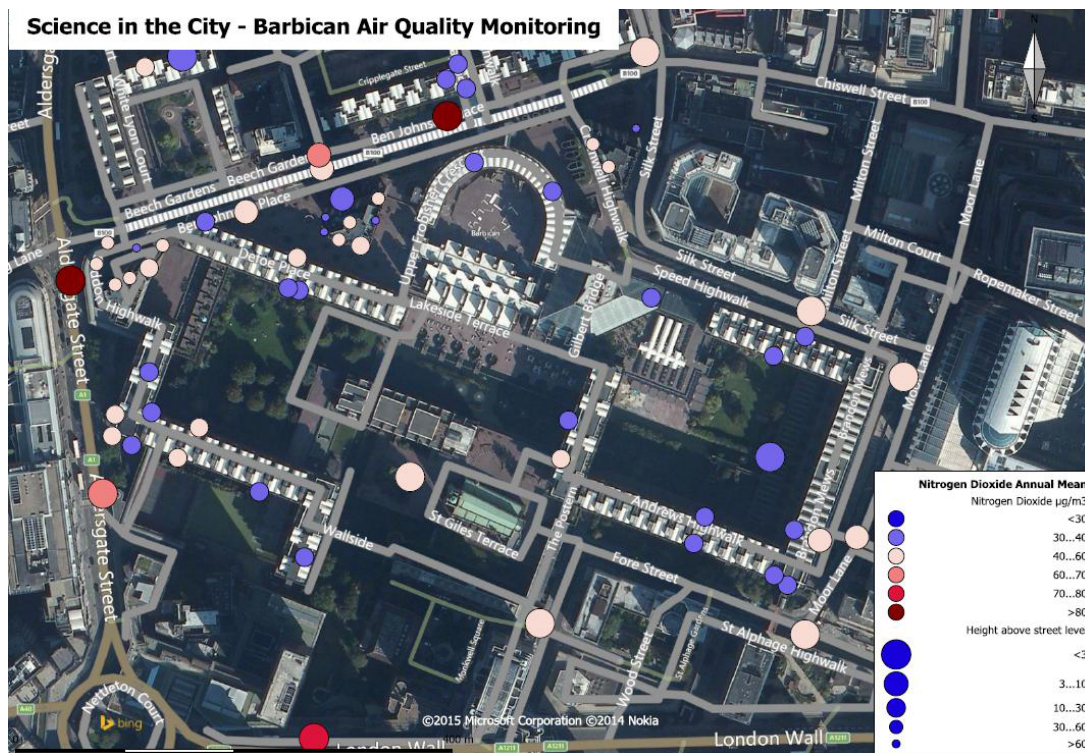
<sup>2</sup> See for example this news article : <http://www.standard.co.uk/news/health/city-pollution-blackspots-revealed-amid-warnings-square-miles-air-is-too-toxic-for-joggers-10299351.html>

<sup>3</sup> <http://www.standard.co.uk/news/london/farringdon-street-in-the-city-is-the-worst-place-for-toxic-pollution-in-london-a3270791.html>

done to reduce pollution. Two further meetings were held throughout the project to feedback results, maintain momentum and encourage discussion on key actions to take to improve local air quality.

With guidance from Mapping for Change, the Barbican residents put up diffusion tubes monitoring nitrogen dioxide in well-defined, specific sites. The diffusion tubes were left exposed for four weeks before being collected, re-capped and replaced with a new tube. The end time and date were recorded so that the exposure time, in hours, could be calculated. The tubes were collected by the local organiser and sent to the Mapping for Change research team and laboratory for analysis. This was repeated each month between October 2013 and September 2014, with the same pool of volunteers. Sixty five (N=65) NO<sub>2</sub> monitoring sites provided regular data over the one year period. All results for nitrogen dioxide monitoring were digitised using an interactive community map, plotted on graphs and shared via email with the residents involved. See Figure 2 for an example of the kind of maps that were produced.

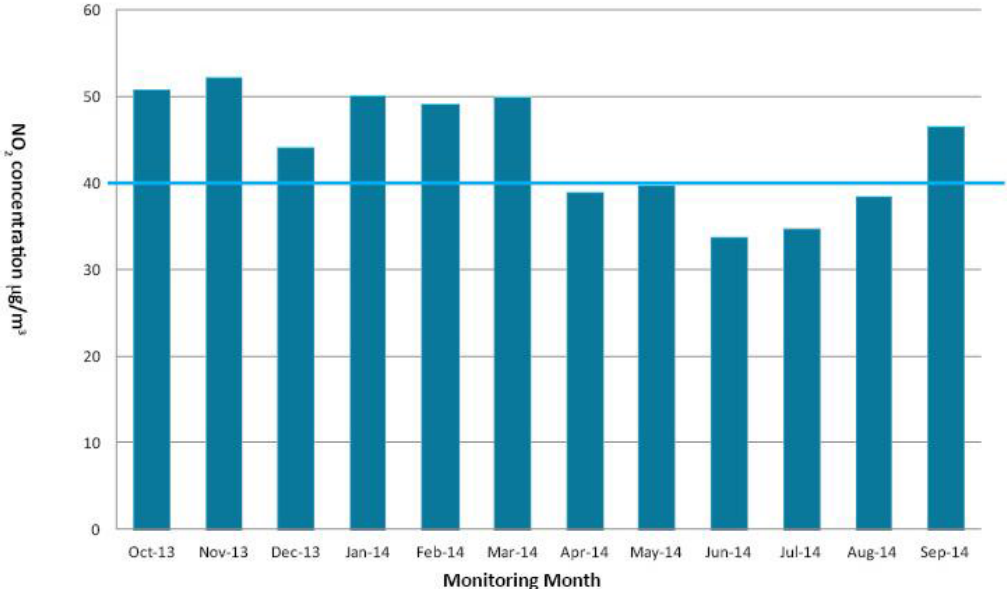
**Figure 2. Nitrogen dioxide annual mean at each monitoring site across the Barbican and height from street level (Francis & Stockwell, 2015)**



In parallel, the participants had the opportunity to volunteer for monitoring their personal exposure to particulates (PM<sub>2.5</sub>). The routes and monitoring periods were selected by the resident so as to be more representative of their daily routines. These included static readings such as on the balcony outside their residence, journeys around the Barbican, their daily commute and several trips further afield. The SidePak aerosol monitor was charged up, switched on and calibrated prior to each use. Activity was recorded by the participant in a diary. The GPS data was synchronised with the SidePak data using time as the constant to match the two datasets. Journeys and PM<sub>2.5</sub> readings were mapped and shared with the

resident surveyor. Once anonymised, the maps were shared with all the residents at a workshop and via the website.

From an environmental perspective, the project provided interesting scientific data. The results showed that nitrogen dioxide concentrations measured over the course of the year displayed seasonal variations in line with measurements taken over previous years from local authority managed monitoring stations. A number of locations, such as Beech Street Tunnel and London Wall, were found to have concentration levels exceeding the EU annual targets (see Figure 3). The interior of the estate, however, proved to be less exposed to the same poor air quality as that at street level, although residents living in the towers overlooking Beech Street were still exposed to potentially harmful concentrations of pollutants, even up to a height of sixty meters (Francis & Stockwell, 2015)<sup>4</sup>. Mapping for Change took on a similar advisory role with the other shorter projects (in Catford, Hackney, etc.) – introducing residents to monitoring tools and mapping methods, and helping them to get started with air quality monitoring in their local areas.



**Figure 3: Monthly average reading of NO<sub>2</sub> across the Barbican Estate Oct13 - Sept14. The blue line indicates the EU target of 40µg/m<sup>3</sup>. (Francis & Stockwell, 2015)**

Mapping for Change have carried out surveys to gain a better understanding of the demographics of volunteers. For example in 2014 (Francis & Stockwell, 2015), they surveyed 31 Barbican residents and found that the majority of participants were female (65%), the most popular age category was 64+ years (37%), the majority had lived in the Barbican for more than 3 years (81%), most had heard about the project via email (71%), and most thought air quality was “often very poor” (40%) or “sometimes bad” (33%). A complementary research project was set up to further investigate the experience and motivations of the participants, as well as the different kinds of learning and creativity that volunteers encounter.

<sup>4</sup> Mapping for Change project report is available online : [http://mappingforchange.org.uk/wp-content/uploads/2015/08/Barbican-Final-Report-draft\\_12012015\\_edited.pdf](http://mappingforchange.org.uk/wp-content/uploads/2015/08/Barbican-Final-Report-draft_12012015_edited.pdf)

## 2. Motivation, learning and creativity in citizen science

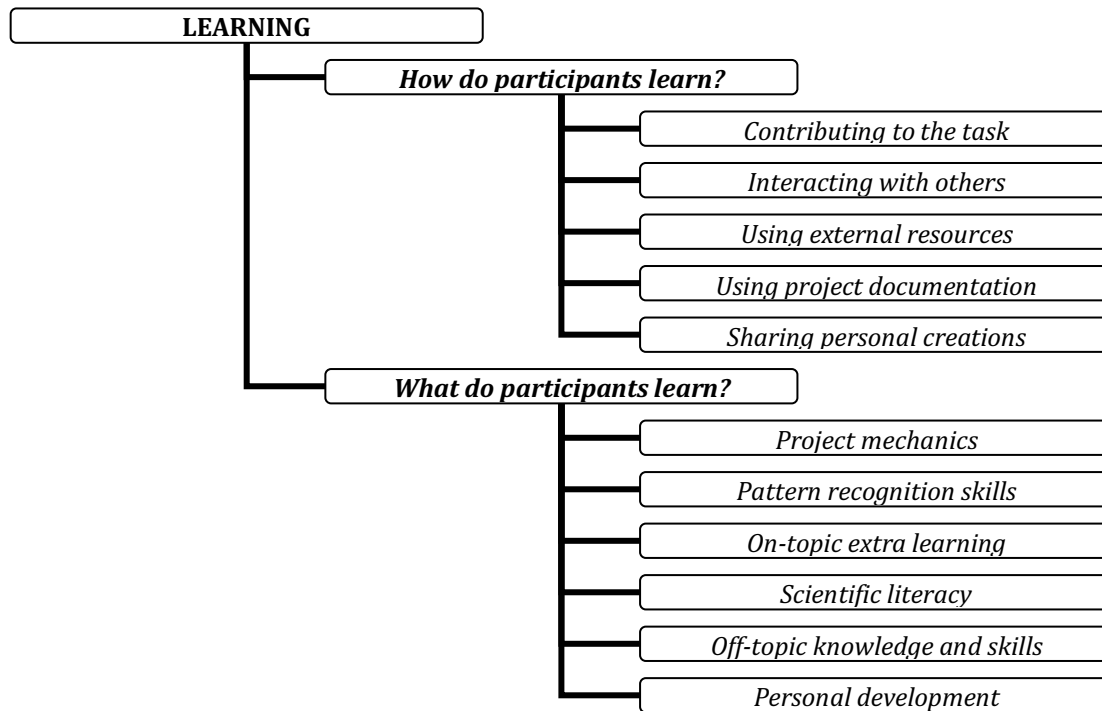
In citizen science, volunteers work with professional scientists to carry out scientific projects. Examples include naturalistic, fieldwork projects like the Cornell's lab ornithology projects, or the famous British Christmas Bird Count, as well as online projects, such as Galaxy Zoo (where volunteers categorise images of stars) and Eyewire (where volunteers colour in images of retina neurons). The Science in the City AQM projects can also be thought of as citizen science projects. However, rather than the scientists leading the project direction with help from volunteers, it is the volunteers (local residents) who are leading the project direction with help from the Mapping for Change science team. These projects are referred to as « extreme citizen science » (Haklay, 2010, 2013). By definition, citizen science projects pursue scientific goals. However, they also display specific social dynamics. A research focus on the participation patterns and experience of the volunteers is emerging in the community of scholars interested in these new forms of collaboration between citizens and scientists, as well as a more recent research interest for the educational opportunities that they may offer.

From an educational perspective, participation to citizen science projects has been demonstrated to trigger environmental awareness and improvement in scientific literacy (Ballard & Belsky 2010; Bonney et al., 2009a, 2009b ; Crall et al., 2012 ; Cronje et al., 2011; Jordan et al., 2011), topic-specific content knowledge (Jordan et al., 2011; Crall et al., 2012) and changes in everyday behavior (Crall et al., 2012; Jordan et al., 2011). Recently, some researchers have also argued that participants may experience a much wider range of learning outcomes, depending on their engagement in the projects (Kloetzer et al., 2013; Jennett et al., 2016; Kloetzer et al., in press). They have also highlighted that learning in a social community of volunteers supports sustained participation in citizen science projects (see also Curtis, 2015; Price & Lee, 2013; Rotman et al., 2012, 2014). The balance of scientific and educational goals in citizen science is therefore complex.

In parallel, educational researchers and teachers working on science education have investigated authentic science as a way to convey scientific literacy and passion among students. Inquiry-based learning approaches, for example, create situations in which students can mimic and experience the scientific reasoning. Well-structured approaches based on authentic science – or science-mediated scaffolding of students investigation - have proved useful for science education (see for example, a synthesis in Hmelo-Silver et al., 2006). As also demonstrated in other chapters of this book, there are good reasons to think that citizen science, which allows to engage volunteers in authentic scientific activities, may therefore provide good opportunities for learning and science education.

In our previous work (Jennett et al., 2015), we interviewed 28 volunteers and 11 scientists from several online citizen science projects (including Old Weather, BOINC, Eyewire, Bat Detective) to find out more about their motivations for taking part, and their experiences of learning and creativity. Our thematic analysis revealed that volunteers are motivated to keep contributing to a project if they feel like they have an aptitude for the task, they enjoy the task, and/or they enjoy participating in the activities surrounding the project (forums, chats). The most dedicated volunteers appear to get into a rhythm of regular contributions and they become increasingly familiar with other volunteers over time, becoming part of the core community.

Activities through which volunteers learn can be categorized according to two levels: at a micro level, that is direct participation in the task; and at a macro level, for example, use of project documentation, personal research on the Internet, and practicing specific roles in project communities. Generally, the more aspects volunteers participate in the project, the more they learn. See Figure 4 for a full typology of the different ways in which participants learn and what they learn.



**Figure 4. Thematic map of volunteers' learning (Jennett et al., 2016)**

Creativity is an important and controversial aspect of participation and learning in online citizen science projects. Although volunteers feel that strict compliance with the scientific process guarantees the quality of their contribution, they sometimes offer powerful suggestions or creations to improve the project. Therefore, at the microlevel, engaged volunteers tend to follow the scientific protocol strictly and « uncreatively », whereas at the macro level, they might develop and share personal creations, as they are motivated by their sense of belonging to a community, and their desire to improve the project. Community-enhanced gamification, forum discussions, sharing of interesting or amusing pictures, creation of artwork, provided excitement and enhanced the life of the community. Volunteers also shared the project with others via outreach activities, providing new ways for the community to grow.

Based on our findings, we proposed the MLC model (Jennett et al, 2016), where we explain that motivations, learning and creativity are connected. The more a volunteer participates in different aspects of a project (micro and macro-levels), the more they learn and the more their identity as a project volunteer deepens. Identifying as a project volunteer involves three aspects: self-confidence, feeling that they are contributing to research, and feeling that they belong to the project community. Learning is then connected to sustained participation

through these mediations. Some participants may also produce some personal creations as a way to solve various challenges emerging in the course of participation, which also increase their motivation to participate and impact recognition of the importance of their contribution in the community. Therefore, creativity seems to be strongly related to engagement: it can optimize both an individual's activity and the project itself.

### 3. Exploring motivation, learning and creativity in AQM

Building upon our previous work and the MLC model (Jennett et al., 2016), we decided to carry out a similar interview study with volunteers of the Science in the City AQM projects. Will we uncover similar themes for motivation, learning and creativity in the context of Science in the City? Or will we uncover different themes because these are local community-driven citizen science projects, as opposed to online scientist-led citizen science projects?

The research questions of the study were as follows:

- Which are the motivations of the participants to the AQM projects?
- Are there initially any learning expectations among the volunteers, and how do they evolve during the project?
- Which are the learning outcomes they experience from participating to the AQM projects?
- Which kind of activities and processes contribute most to these learning outcomes?
- Are there creative outcomes related to participation in the AQM projects, and how do they relate to motivation and learning?

14 participants were recruited via an opportunity sample. Mapping for Change sent an email to participants of all of the Science in the City AQM projects, explaining that we were interested in interviewing participants about their experiences of AQM. 14 participants replied to the email volunteering to take part: 9 participants (52 to 87 years old, mostly retired people and independent workers) who participated during 12 months to the Barbican project (2013-2014); 5 participants (30 to 44 years old) who participated to 1 month-long replications and extensions of the Barbican project, in diverse areas of London (Westway, Catford, Hackney, Streatham, Silvertown) in 2014 and 2015. It is probable that these participants may be more engaged than average participants, as they were confident enough to volunteer to be interviewed (i.e. self-selection bias). However, in we emphasised that we were interested in hearing about people's bad experiences of the project as well as good experiences.

The interviews were carried out either face-to-face or by Skype. They were audio recorded and lasted between 30 minutes and 1 hour. The resulting transcripts were analysed using Thematic Analysis (Braun & Clarke, 2006).

#### *Motivation to participate*

In our analysis we distinguished between motivations for initial participation and motivations for sustained participation. See Table 1 for an overview of the different themes.

**Table 1. Motivation themes in the AQM interviews**

	<b>AQM London</b>
<b>Participation</b>	<ul style="list-style-type: none"> <li>• Hosting an air monitor for several months, every month sending</li> </ul>

<b>involved:</b>	<p>data and replacing monitor, optional meetings</p> <ul style="list-style-type: none"> <li>• Additionally for those leading the project: bid for funding, coordinating with Mapping for Change, meetings with residents, writing magazine updates, local newsletter, email reminders to residents, forums, social media, liaising with press, setting up meetings with MP and council</li> </ul>
<b>Initial participation</b>	<p><i>Personal health</i></p> <ul style="list-style-type: none"> <li>• Suffer with asthma, respiratory problems, or a family member that suffers</li> <li>• Worried about effects of pollution on young children</li> </ul> <p><i>Interest in environment</i></p> <ul style="list-style-type: none"> <li>• Involved in local green party</li> <li>• Building on an earlier campaign, want to expand this work and engage more people</li> <li>• Interest in recycling, pollution, conservation, green urban spaces</li> <li>• Raising awareness about air quality – “you can feel it is polluted”</li> </ul> <p><i>Helping others in local area</i></p> <ul style="list-style-type: none"> <li>• Asked by friends to help put up tubes</li> <li>• Read an advert in the residential newsletter, forum</li> <li>• Nice to live in a place where people take care of the environment</li> </ul> <p><i>Lobbying for change</i></p> <ul style="list-style-type: none"> <li>• Interested in improving things</li> <li>• Want to collect real evidence to persuade authorities to do something, help to build up a case – “it’s good to have data”</li> <li>• Want specific improvements – e.g. I want the council to do more monitoring, I want TFL to change buses to hybrids</li> </ul>
<b>Sustained participation</b>	<p><i>Practical</i></p> <ul style="list-style-type: none"> <li>• Doesn’t require much effort to host a monitor</li> </ul> <p><i>Community</i></p> <ul style="list-style-type: none"> <li>• Nice feeling that everyone is working together</li> <li>• Enjoy publicising the project and engaging with others</li> <li>• Positive feedback from the community</li> <li>• Status – becoming more well known to residents</li> <li>• Feeling empowered, that you can make a difference</li> </ul> <p><i>Research</i></p> <ul style="list-style-type: none"> <li>• Sense of agency - we choose where to put up the monitors, which area to cover</li> <li>• Excited by the idea of citizen science, that you can do it by yourself</li> <li>• Want to do your part in collecting good data, contributing to a bigger study</li> <li>• Learning the results increases your motivation</li> </ul> <p><i>Accessibility</i></p> <ul style="list-style-type: none"> <li>• Easy to understand, no intimidating jargon</li> <li>• Like that it involves people who are not usually involved in science experiments</li> </ul>

We comment here two main findings. Firstly, the bedrock to participation to AQM projects is previous sensitivity to environmental issues. This personal sensitivity can be grounded in various personal experiences, for example, some participants complained about respiratory problems, including asthma, in their family. As two interviewees explained: *“I’m interested in air quality because I’ve had respiratory problems and I have a young child and you know there are problems...”* (Participant, Barbican project), *“I have chronic asthma and I have found that the traffic... the traffic pollution makes it worse. I had found that even with the inhalers, it seems to be a constant problem...”* (Participant, AQM project). This existing environmental sensitivity is reinforced by existing local networks and social connections, which enable potential participants to hear about the project. Therefore, participation is triggered by a wish for efficient political action, in which scientifically-grounded data play an instrumental function. As one participant explains: *“I was obviously very interested to ensure that we were getting... collecting real evidence to try and persuade the authorities to do something about improving air pollution.”* (Participant, Barbican project).

Secondly, consistently with what we observed in other citizen science projects, participants' initial motivations were found to evolve throughout the project. Feelings to contribute efficiently in a community, varied unexpected informal learning experiences, and social dynamics, played critical role in sustained participation. As two participants note: *“I really enjoyed meeting a whole new roster of people on the estate [...] And it’s a very nice feeling when everybody is working for a common objective”* (Participant, Barbican project); *“What was really nice, it’s a citizen science project, to get more and more people involved and it’s something that you can do yourself.”* (Participant, Barbican project).

### *Learning through citizen science*

In their internal survey with Barbican residents, Mapping for Change found subjective evidence for air pollution awareness in the project. Over 90% of respondents agreed that their understanding of the health impacts of air pollution had improved as a result of participating in the project. Residents were asked how they felt about air quality around the Barbican Estate. The responses showed that at the start of the project 40% of residents felt it was often very poor and 20% always very bad, whereas 59% and 14%, respectively, felt this way at the end of the project. Only 7% believed air pollution was not really a problem at the start of the project. When asked if the project had made residents aware of any measures the local authority undertakes to monitor and improve air quality in the city, 92% agreed it had, however, only 23% felt ‘sufficiently’ informed about its work to reduce air pollution.

This survey also provided evidence for some behavioural change: 82% percent of respondents agreed they would make changes to reduce their personal exposure and contribution to air pollution as a result of the project including, ‘greening up’ their balconies with air-filtering plants, avoiding Beech Street tunnel and other hotspots, reducing their use of private transport and collecting parcels rather than having them delivered. As a direct result of the NO<sub>2</sub> monitoring, some residents have decided to only open the windows of their flat that face inwards into the Estate rather than a roadside window or avoid opening windows and vents at peak traffic times. The project also supported the residents in making various, structured suggestions to the City Corporation (the local government) including, ‘Greening up’ the area

with more trees, plants and living walls, closing Beech Street tunnel to traffic or improving its ventilation, introducing penalties for idling taxis, delivery vehicles and buses, encouraging the use of electric buses and private vehicles by promoting and installing more charging points in the area and extending the Ultra Low Emission Zone.

We found that our interview study complemented these survey findings, while at the same time providing a more in-depth understanding of the wide variety of learning outcomes that AQM volunteers experience. See Table 2 for a summary of the main learning outcomes and main learning processes from participation in AQM projects.

**Table 2: Learning themes in the AQM interviews**

	<b>AQM London</b>
<b>Learning outcomes</b>	<p><i>On topic knowledge</i></p> <ul style="list-style-type: none"> <li>- Distribution of pollution in time, space and height</li> <li>- Day-to-day variations of pollution according to atmospheric and traffic conditions</li> <li>- Different kinds of pollutants</li> <li>- Accepted pollution levels in Europe and effects on health</li> <li>- Link between taxi and car traffic and air pollution</li> </ul> <p><i>Awareness and community engagement</i></p> <ul style="list-style-type: none"> <li>- Raising awareness of the issues of air quality</li> <li>- Strengthening community feeling and community engagement</li> <li>- Better knowledge of the neighbourhood</li> </ul> <p><i>Public Participation and Citizen Science</i></p> <ul style="list-style-type: none"> <li>- Understanding how citizens can be involved in air quality monitoring</li> <li>- Increasing political expectations towards the City Council</li> <li>- Nurturing political claims by local communities</li> </ul> <p><i>For the coordinators</i></p> <ul style="list-style-type: none"> <li>- Communication and coordination, interpreting scientific results, mapping, writing synthesis</li> <li>- Using the tools and software</li> <li>- Leading a campaign through social media</li> </ul> <p><i>For some engaged participants</i></p> <ul style="list-style-type: none"> <li>- Creative ways of raising awareness and communicating findings</li> </ul>
<b>Learning processes</b>	<ul style="list-style-type: none"> <li>• Physical engagement (“I carry a ladder”)</li> <li>• Collective project (they do it as a community)</li> <li>• Cross fertilization of the local residents community and the project community, therefore, pre-existence of a strong local community helps a lot</li> <li>• Collaboration with scientists</li> </ul>

First, people mostly enjoyed the experience, especially the feeling to be able to contribute efficiently as a community, although they had no prior experience in the field. As one participant explained: *“It just felt great that a group of volunteers that had no experience of collecting pollution data were just able to go out there and run a project and then you send it off and get some real data that’s valuable, you can put it to good use and you can deliver some results from it. So I really enjoyed that aspect of this, I keep mentioning citizen science, but I just think it’s really exciting that more and more things can be done from this approach”* (Participant, Vauxhall project).

Second, participants' learning expectations were connected to their main motivations for participating to this project, i.e., building a strong case backed up with scientific data to support their political action as a community. Reinforcement of the community feeling also contributes to empowerment of the community in this activist stance, and is therefore perceived as valuable. As two participants explain:

- *“I wanted to learn more about the mechanics of setting up an air quality monitoring system with a bunch of neighbours”* (Participant, Westway project)
- *“I was so interested in the final results. I think, we all thought that air quality was going to be very poor just around personal experience, and that it was a real issue. And it was very nice to be able to actually get data to have us back that up because when you’re asking questions in the meeting, you don’t have an idea of what to say. (...) It’s nice to have the data up your sleeves to be able to present a case. So yes, I mean, I did learn a lot over the course of this, and I mean you’re constantly picking up articles, people are sending links to you about other air quality incidents or data that’s coming in from some other academic study or mapping for change type study. So you do get very much more up to speed over the course of the project”.* (Participant, Barbican project)

Third, the project triggered learning about air pollution, including a more complete and precise view of its components, risks for health, and day-to-day variations, as well as personal environmental awareness. As these were two expected educational outcomes of the project, the project can be considered successful on its educational dimension. For example, the project brought a more detailed and nuanced understanding of air pollution:

- *“I think I learned that rather than a generic term "air quality" that there are lots of different components, so looking at the Mapping for Change website, there were lots of different layers that you could switch on and off. It made you more aware of beyond nitrogen dioxide being a pollutant, that you also are looking at different particulates, so I think it gave you more of an in-depth insight and particularly which things might make you short of breath as a cyclist. (...) And why these different components of the air quality have a different effect and why some are more important than others to focus on.”* (Participant, Barbican project)

Another participant explained how the project changed their initial “modelling” of air pollution concentration and diffusion:

- *“And because it lasted for a year, we actually got some very meaningful data, which could be used hopefully to change some of the modelling of the air quality model where it shows that there’s very high concentrations along roads and then it drops off quite markedly into the spaces, sort of a few hundred meters away. We*

*found that that actually wasn't the case. That even at height, 34th floor, looking away from the road on some of the tower blocks, the concentration was high or if not higher than down at street level. And in the garden, some flats that have slowed down for the rise in greenery had levels of nitrogen dioxide below the safe levels for health. But there were an awful lot across the estate where the really average level was well-above the safety limit for health. So it probably has changed people's views of the original modelling that was done" (Participant, Barbican project)*

Fourth, as observed in other citizen science projects, the project triggered a bunch of diverse, unexpected learning outcomes, related to the specific roles that some highly engaged participants had in the project, especially as local coordinators. As explained by one participant:

- *"In terms of leading the campaign, I've learned loads about social media and marketing. I wasn't on Twitter before, I'm on Twitter, I now have a community group page on Facebook. I've learned loads about marketing and media generally as well, I've been on Radio 4, Radio 5, BBC London Tonight, Channel 4, so local and national media, mostly national actually, and that has been really exciting to learn more about how the whole thing works. So I've learned about marketing and so on." (Participant, Hackney project)*

Fifth, local, physical engagement in the project, mediated by simple tasks (like installing, checking and changing the diffusion tubes), seems to be a fundamental aspect of the whole engagement process. By providing emotional, collective engagement within the city, it impacts both one's view on one's neighbourhood, and relations with others in the local community. As one participant details:

- *"This participation in the air quality monitor project was different because it was actually physically being involved whereas in the past that's mainly just listing emails to people and... I mean it's actually important learning to have to do it together in the community and it's definitely changed the nature of the engagement to being just more people orientated. (...) I learned about the neighbourhood. I mean I learned more about the neighbourhood and details of where all the schools are and where all the playing pitches are and where the community is most affected by bad air and the level of pollution, dust pollution from local construction sites and that they're not always following the rules around air quality management. (...) There was certainly a tangible lesson in how people can actually be involved in monitoring the environment. (...) I enjoyed meeting the other people and seeing that there's some shared concern about these issues". (Participant, Westway project)*

### *Creativity in the AQM projects*

Creative outputs are interesting, as they offer specific windows on the strong engagement of some volunteers in the project. In the AQM projects, the creative activities spontaneously carried out by the volunteers were oriented towards promoting the project, communicating its findings and using them in air quality lobbying. As appears in Table 3, these were driven by the activist stance of participants.

**Table 3: Creativity themes in the AQM interviews**

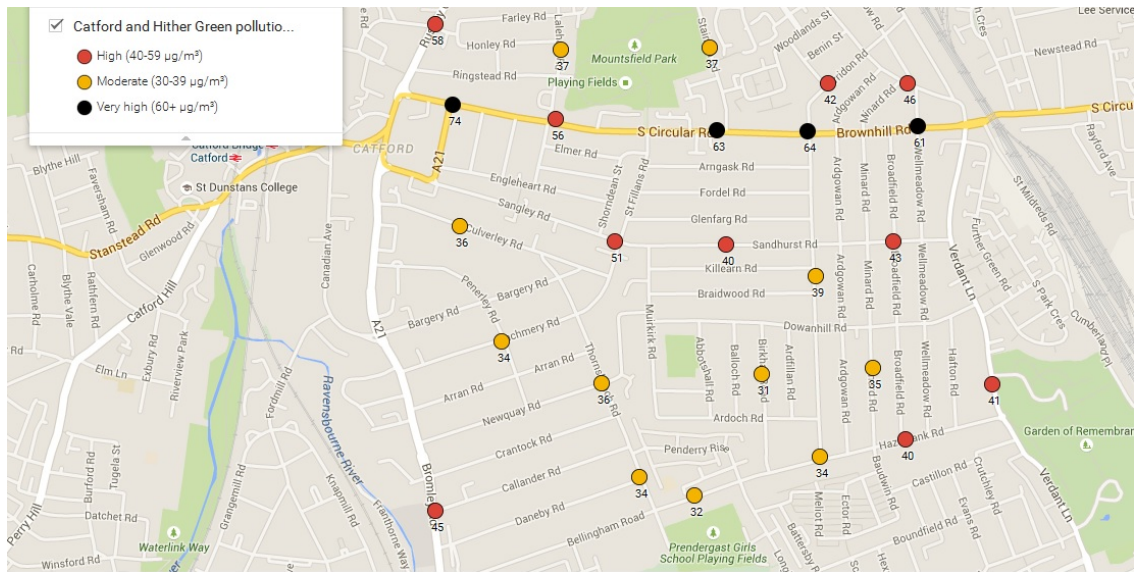
	<b>AQM London</b>
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<b>Creative activities</b>	<p><i>Promoting the project</i></p> <ul style="list-style-type: none"> <li>• Coming up with ideas to raise awareness</li> <li>• Designing promotional materials: posters, flyers, T-shirts</li> <li>• Communicating findings: posters, flyers, newsletters, press releases</li> <li>• Organising events : « Air Champion Fair »</li> <li>• Incentives – e.g. time credits</li> </ul> <p><i>Presenting the data in a different way</i></p> <ul style="list-style-type: none"> <li>• Creating own google map with different colour scheme</li> <li>• Creating posters and flyers to feedback results of project to community</li> </ul> <p><i>Lobbying against air pollution</i></p> <ul style="list-style-type: none"> <li>• Thinking of ways to use data to lobby against air pollution</li> <li>• Suggesting ways to improve air quality</li> </ul>
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Volunteers wrote newsletters and press releases to promote their projects. For example, they organised a community fair and created a newsletter to publicise this event. Creative outputs were driven by the challenges of the project, here, engaging others with scientific data which might appear as not too engaging for non scientists. As exemplified in these quotes, the efforts of volunteers focused on communication and engagement issues in creative ways:

- *“We’ve got t-shirts we produce for kids to wear, and we distribute flyers at events. So the kids all wear these black and white t-shirts with “smog off” and “diesel no tar” and “clean air tastes good”, and they pass these out to passers-by while the parents just hang around. So that’s good, one of our big events we do to raise awareness around the public, and if you invite press to it they come because it’s cute kids dressed up as super heroes raising awareness.” (Participant, [project](#))*
- *“And then once you get the data, the greatest creativity from us comes in the production of the flyer. The flyer is critical, it’s the point of communication between us and the parents we want to reach, so what we do is produce a flyer and we also produce a poster as well. The maps are alright but the maps to be honest are data heavy. They are interesting to parents that walk around those schools, because they want to see where the most polluted roads are, but if someone is just walking past a poster they’re not necessarily going to stop and look at that. So you need to make the whole thing really attractive and eye catching.”(Participant, [project](#))*

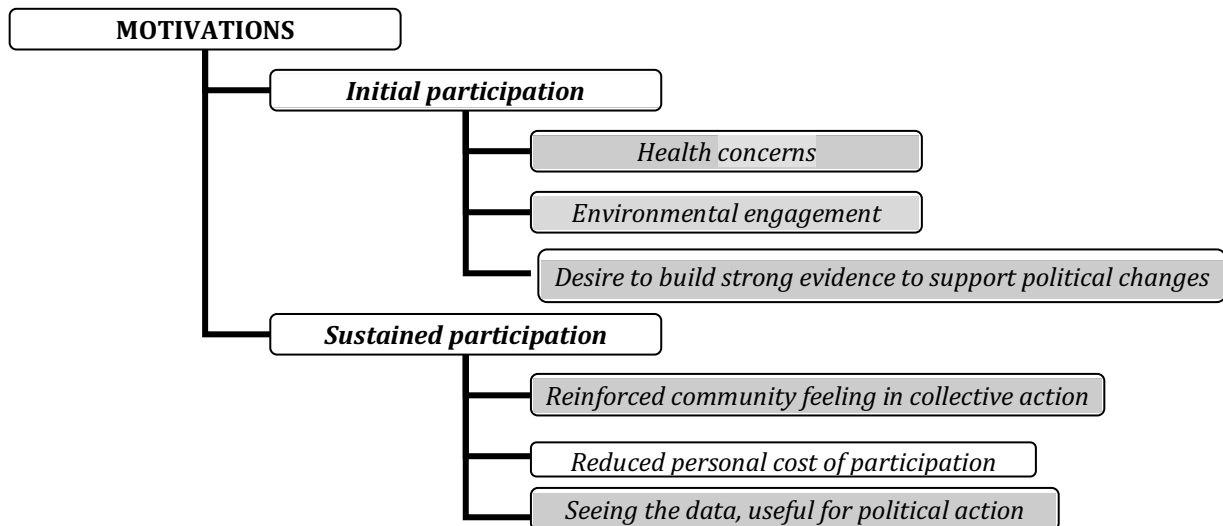
One of the most interesting cases demonstrates how volunteers improved in data visualization and interpretation by changing the color codes of a map to highlight relevant information. They highlighted the high levels of pollution by coding it from orange to black instead of using the more neutral color code chosen by the team at Mapping for Change. This case is interesting as it highlights the tensions around a shared object, here, the pollution map, used by stakeholders and participants with diverse intentions. The rather neutral color code chosen by the scientists aims at displaying the results in the clearest, most readable way (readability being understood here as continuum and contrast) whereas the emergency color code (orange-red-black) chosen by the participants highlighted the overall poor air quality. Thanks to this new colour code, the volunteer highlighted that even the lowest measures done in the local area are close or above the European safety level.



**Figure 5: Google map created by volunteer in Catford project**

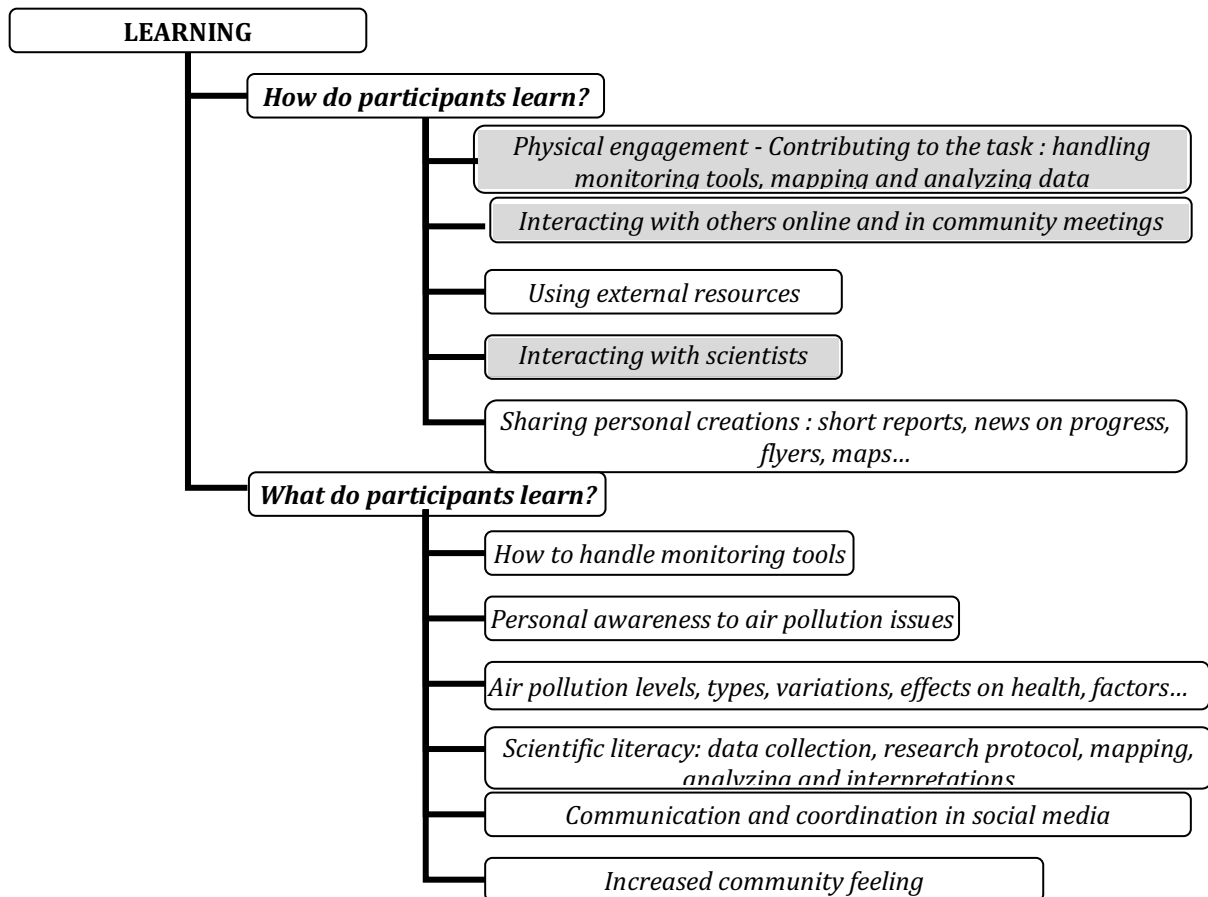
**4. Discussion: Function and transformations of citizen inquiry in AQM projects**

Based on our empirical findings, we can now discuss the function and transformations of citizen inquiry in the project. To do so, we first update the thematic maps of motivation, learning and creativity that we presented earlier in this chapter, for the specific case of the community-centered AQM projects. Our interviews allowed to specify the kind of motivations, learning outcomes, learning processes, and creative outputs that can be expected in a AQM project. Although the sample was quite limited (14 interviews), we believe that it covers a large set of the potential outcomes of this kind of projects, as the volunteers interviewed were most probably engaged volunteers with a broad range of experiences. We added in grey the major changes between this community-centered project and more scientists-centered online citizen science projects (presented in Section 2 of this paper). The major change is in the profile of motivations: curiosity, interest for science and desire to contribute to scientific research, which are the usual initial drivers for online citizen science project volunteers, are replaced by more specific interests: personal or family health concerns linked to air pollution in the City, environmental engagement, desire to build strong evidence to support political change. Sustained motivation is also connected to the potential of data analysis for political action. Therefore, project participation is strongly grounded in the interest of the participants for increased air quality; our volunteers were found to engage into personally meaningful scientific investigations.

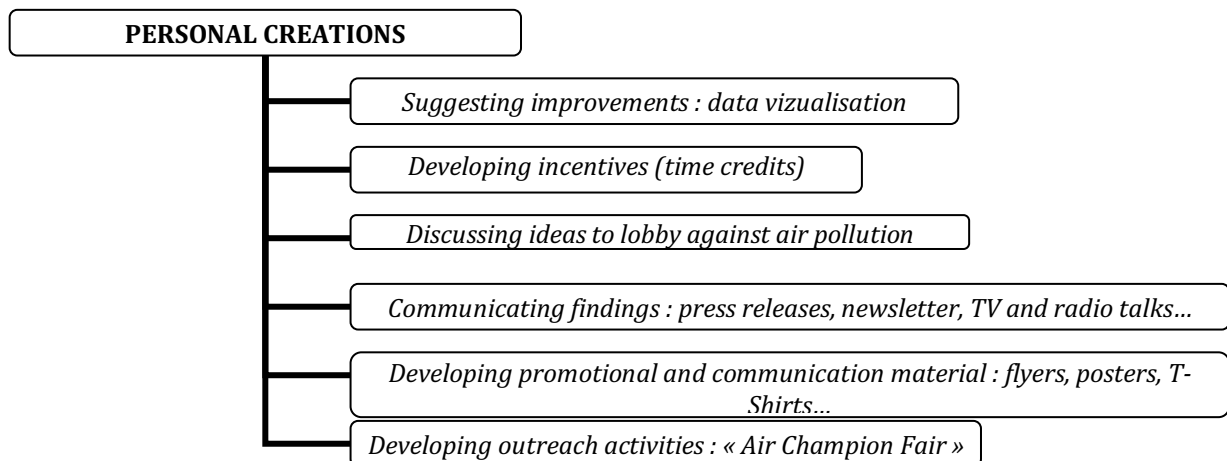


**Figure 4.1.** Thematic map of volunteers' motivations in a community-centered AQM citizen science project

How did this personal significance affect the learning outcomes and processes at stake? Interestingly, it did not change much of the type of learning outcomes experienced by the volunteers, nor of the type of learning processes. However, these experiences seem to be mediated, in the case of AQM volunteers, by three specific dimensions: physical engagement, community engagement, and direct interaction with scientists – these three dimensions themselves get transformed in the research process. Refraction of one's own experience in a local community of neighbours, with at least partially shared concerns, reinforces both the personal experience and the community. Personal physical connection with the city gets enhanced and transformed by the scientific protocol that volunteers agreed to follow, by the resulting maps, and by their discussions in the local community. Interactions with scientists may bare the contradictions of different projects, as the case of the re-coloring of the final map shows. Compared to other citizen science projects, the AQM project seems therefore to be different because it is directly connected in the everyday life and concerns of the volunteers.



**Figure 4.2** Thematic map of volunteers' learning in a community-centered citizen AQM science project



**Figure 4.3.** Thematic map of volunteers' creations in a community-centered AQM citizen science project

Citizen inquiry initiates and grounds the whole citizen science process. The personal meaningful inquiry gets transformed through collaboration in the citizen science projects. The process of carrying out the research involves personal engagement performed in structured collaboration with community leaders, neighbours and scientists, within a network of volunteers.

This personal impulse turns into a meaningful scientific activity by the mediation of the scientists providing tools, methodologies, standards, literature, background information, concepts, framing discourse, powerful and valuable ways of doing. We have here a scientific empowerment, in the sense of empowerment by science.

The personal impulse also gets collective. Volunteers discover that their concerns are shared by friendly, active neighbours. They collaborate by setting research questions, defining the methodological design, collecting data, analysing and mapping data, interpreting them, sharing findings and reflections in short reports and meetings, and suggesting and taking actions. They create outreach events, innovative ways of communicating and gathering people. Volunteers experience stronger community feeling through shared concerns, shared fun activities and shared findings. This is a kind of community empowerment, in the sense of empowerment of and by the community.

Although learning outcomes and creative activities may look similar to what has been observed in other types of online citizen science projects, the kind of personal inquiry which grounds the project impacts all their experience. Volunteers evaluate data collection, scientific findings, their own learning and creative engagement with the project, against their strong personal interest in improving air quality.

#### **Figure 4.4. Dynamic double empowerment process through AQM.**

Citizen inquiry, from personally meaningful, gets transformed in the process of participating to the citizen science AQM project by a double empowerment: scientific empowerment, and empowerment by the community. Citizen inquiry can then contribute to transforming these two mediations, innovating in the scientific process and strengthening the local community. However, our analysis highlights the critical role of the existing local communities and networks of interests in this virtuous circle. Existing local communities mediate the encounter of personally meaningful topics and scientific knowledge, tools and research methodologies. They play a role in the carrying out and diffusion of the project. They get transformed and strengthened in the process through learning and an increased feeling of belonging of their individual members. However, without these pre-existing local communities, the whole process of engagement into citizen inquiry turns out to be more difficult. The emergence and existence of the project are allowed by the joint efforts and engagement of the local citizens (providing initial interest, local knowledge, time and a lot of ideas), the scientists (providing scientific expertise, technical support in the choice and use of monitoring tools, laboratory analyses, mapping techniques, co-design of research protocol, analysis and interpretation of the data, scientific writing, scientific literature), and the City authorities (providing funding and interest for the findings) – grounded in local networks and communities.

## Conclusion

In this chapter, we reported on the Science in the City AQM (Air Quality Monitoring) project, facilitated by Mapping for Change, and dedicated to collaboratively gathering and mapping data on air pollution. Design of the research, data collection and mapping, interpretations of the findings, reporting and communication on the project were performed by local volunteers collaborating with scientists. The initial citizen inquiry, driven by local concerns on pollution levels that were subjectively experienced as high, led to the implementation of a monitoring protocol of nitrogen dioxide (NO<sub>2</sub>) and particulates, which triggered rich scientific findings, highlighting high levels of pollution as well as its variability. It also triggered diverse and sometimes unexpected learning among participants, depending on the activities endorsed by volunteers, including increased knowledge on air pollution in the city (understanding of the distribution of pollution in time, space and height as well as of the main effects of pollution and factors affecting it), increased environmental awareness, increased community identity, and sometimes development of communication skills on various media.

We show how personally meaningful inquiry grounds participation to the whole project, how it gets transformed in the process thanks to a double empowerment, by the scientific team and by the local community, and finally how it drives the subjective evaluation of the whole project, including its scientific findings and the volunteer experience, which are evaluated against citizens' strong personal interest in improving air quality. Our paper finally highlights the critical role of local communities in mediating the encounter between scientists and volunteers around partly shared interests.

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## References

Ballard, H. L., & Belsky, J. M. (2010). Participatory action research and environmental learning: Implications for resilient forests and communities. *Environmental Education Research*, 16(5-6), 611-627. CHI'15: Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems, 4069-4078.

- Bonney, R., Cooper, C. B., Dickinson, J., Kelling, S., Phillips, T., Rosenberg, K. V., & Shirk, J. (2009a). Citizen science: a developing tool for expanding science knowledge and scientific literacy. *BioScience*, 59(11), 977-984.
- Bonney, R., H. Ballard, R. Jordan, E. McCallie, T. Phillips, J. Shirk, and C. C. Wilderman. (2009b). *Public participation in scientific research: defining the field and assessing its potential for informal science education*. Center for Advancement of Informal Science Education, Washington, D.C. Lastly retrieved on Dec 12th 2016 from <http://www.birds.cornell.edu/citscitoolkit/publications/CAISE-PPSR-report-2009.pdf>
- Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77-101.
- Causser, T., & Wallace, V. (2012). Building a volunteer community: Results and findings from Transcribe Bentham. *Digital Humanities Quarterly*, 6(2).
- Cooper, S., Khatib, F., Makedon, I., Lu, H., Barbero, J., Baker, D., ... others. (2011). Analysis of social gameplay macros in the Foldit cookbook. In *Proceedings of the 6th International Conference on Foundations of Digital Games*, (pp. 9–14), Bordeaux, France, June 28 - July 1 2011.
- Crall, A. W., Jordan, R., Holfelder, K., Newman, G. J., Graham, J., & Waller, D. (2012). The impacts of an invasive species citizen science raining program on participant attitudes, behavior and science literacy. *Public Understanding of Science*, 22(6), 745-764.
- Cronje, R., Rohlinger, S., Crall, A., Newman, G. (2011) Does Participation in citizen science Improve Scientific Literacy? A Study to Compare Assessment Methods. *Applied Environmental Education & Communication*, 10( 3), 135-145.
- Curtis, V. (2015). Online citizen science projects: an exploration of motivation, contribution and participation. PhD thesis The Open University. Lastly retrieved on Dec 12th 2016 from <http://oro.open.ac.uk/42239/>
- Francis, L. & Stockwell, H. (2015). Science in the City. Monitoring Air Quality in the Barbican. Final Report, Mapping for Change. Lastly retrieved on December, 12th 2016, from <http://mappingforchange.org.uk/projects/science-in-the-city/>
- Hacklay, M. (2010). 'Extreme' Citizen Science. Paper presented at: London Citizen Cyberscience Summit, Kings College London, London, UK, Sept 2-3 2010.
- Hacklay, M. (2013). Citizen Science and Volunteered Geographic Information: Overview and Typology of Participation. In Daniel Sui, Sarah Elwood, Michael Goodchild (Eds). *Crowdsourcing Geographic Knowledge. Volunteered Geographic Information (VGI) in Theory and Practice* (pp.105-122). Springer :
- Hmelo-Silver, C. E., Duncan, R. G., & Chinn, C. A. (2007). Scaffolding and achievement in problem-based and inquiry learning: A response to Kirschner, Sweller, and Clark (2006). *Educational psychologist*, 42(2), 99-107.

- Jennett, C., Kloetzer, L., Schneider, D., Iacovides, I. Cox, A., Gold, M., Fuchs, B., Eveleigh, A., Mathieu, K., Ajani, Z., Talsi, Y. (2016). Motivations, learning and creativity in online citizen science. *Journal of Science Communication*, 15(3).
- Jordan R.C., Gray S.A., Howe D.V., Brooks, W.R., Ehrenfeld J.G. (2011). Knowledge Gain and Behavioral Change in Citizen-Science Programs. *Conservation Biology*, 25(6), 1148–1154.
- Kloetzer, L., Schneider, D., Jennett, C., Iacovides, I., Eveleigh, A., Cox, A. L., and Gold, M. (2013). Learning by volunteer computing, thinking and gaming: What and how are volunteers learning by participating in Virtual Citizen Science? Proceedings of ESREA 2013: Changing Configurations of Adult Education in Transitional, Book of Abstracts, Session 38, page 24. Lastly retrieved Dec 12th 2016 from <http://ebwb.huberlin.de/aktuelles/esrea/conference-programme/esrea-book-of-abstracts>
- Kloetzer, L., Schneider, D. & da Costa, J. (in press). Not so passive: engagement and learning in Volunteer Computing projects. *Human Computation*.
- Laumbach, R. J., & Kipen, H. M. (2012). Respiratory health effects of air pollution: update on biomass smoke and traffic pollution. *Journal of allergy and clinical immunology*, 129(1), 3-11.
- Price, C. A., & Lee, H. S. (2013). Changes in participants' scientific attitudes and epistemological beliefs during an astronomical citizen science project. *Journal of Research in Science Teaching*, 50 (7), 773–801.
- Rückerl, R., Schneider, A., Breitner, S., Cyrus, J. & Peters, A. (2011). Health effects of particulate air pollution : a review of epidemiological evidence. *Inhalation toxicology*, 23(10), 555-592.
- Rotman, D., Preece, J., Hammock, J., Procita, K., Hansen, D., Parr, C., Lewis, D. and Jacobs, D. (2012). Dynamic changes in motivation in collaborative citizen-science projects. *Proceedings of CSCW 2012*, ACM Press, 217-226.
- Rotman, D., Hammock, J., Preece, J., Hansen, D., Boston, C., Bowser, A., and He, Y. (2014). Motivations affecting initial and long term participation in citizen science projects in three countries. *Proceedings of iConference 2014*, Berlin, March 4th-7th 2014.