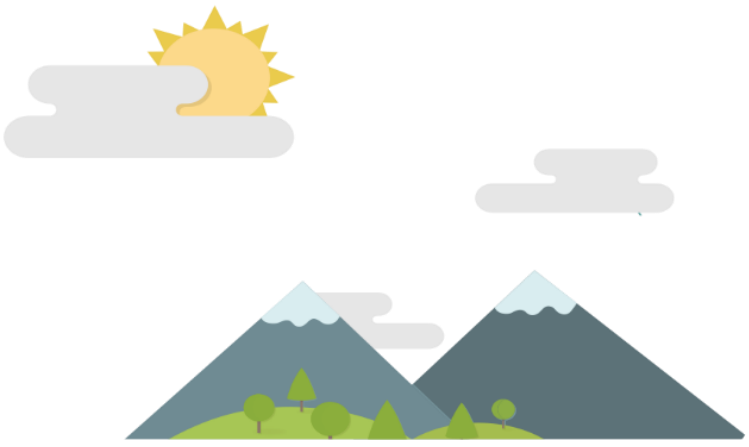
# D7.8: Report on procedures followed and lessons learnt

WP7 – Pilot operation and evaluation



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# 1 Executive summary

Citizen science has becoming an effective tool for the mitigation of several and diverse problems, especially in the environmental domain. Citizen science has emerged as a broad and dynamic set of practices where citizens can now engage with, contribute towards, and direct multiple processes of scientific enquiry. When it goes to air quality, citizens can help in the rapid and low-cost collection of air quality information, filling a well-recognized gap of in-situ data. In that aspect, low-cost sensing devices, either pre-assembled or do-it-yourself kits, are a growing trend that comes to cover the inefficiency of the existing official air quality monitoring networks and satisfy the curiosity and the right of citizens to know the quality of the air they breathe.

hackAIR is a citizen science project aiming to raise public awareness about the problem of air pollution by enabling citizens and communities to have easy access to air quality data and offering them the tools to monitor local air pollution on their own. This was achieved with the development of an open web and mobile platform that aggregates air quality data from various sources and presents them to citizens as easy-to-understand indices, enables them to set up their do-it-yourself sensors and process the measurements, and estimates the air pollution levels from sky-depicting photos that citizens upload to the platform or that are available in social media. The platform was pilot tested in Germany with the active involvement of the grassroot organization Friend of the Earth Germany (BUND), and in Norway with the participation of health associations for almost one year.

The present document is intended for organizers of future citizen science projects to help them better design and implement their projects and achieve the best possible impact. The recommendations listed below are lessons learnt during the implementation of the hackAIR project, have been generalized to cover a wide range of citizen science activities and not only those related to air pollution, and are presented as guidelines for the readers. The ultimate guide on how to design and organize a citizen science project has been provided by the European Citizen Science Association (ECSA) on the "Ten principles of citizen science", and the organizers of future citizen science projects should first advise that document. The current deliverable summarizes the experience of the hackAIR partners that may be of use for future citizen science projects.

# 2 Brief description of the project outcomes

hackAIR is a citizen science project that was implemented from January 2016 until December 2018 by a multi-disciplinary consortium of 9 stakeholders in 5 countries.

The main aim of hackAIR was to raise public awareness about the problem of air pollution and about how each one of us could reduce their contribution to the local air pollution, while motivating at the same time citizens to act as local scientists and monitor the outdoor air quality on their own.

The tools and methodologies developed to assist the hackAIR partners achieve the abovementioned objectives are:

- Discovery techniques of air quality information from **websites and social media posts**
- Air quality estimation from **sky photos,** from webcams, available in social media, or uploaded to the hackAIR mobile app
- Specifications for the assembly of static and portable **low-cost particulate matter sensors**, and of low-tech "measurement" solutions
- Integration of air quality data from various sources and **fusion** of these results
- Activity and health **recommendations** based on the air quality conditions and each user's sensitivities
- Open-source web and mobile **platform** for publishing and visualizing the collected data, and providing educational material about air pollution to citizens
- Online and offline **engagement tactics**
- **Social media monitoring tools** for the identification of trends and potential ambassadors

The technical team faced several difficulties and managed to overcome them. For example, although it was expected that Instagram would be the main source of sky photos, it changed its privacy policy when hackAIR was at an early stage, not allowing to third parties to use its users' photos, so we replaced Instagram with Flickr. Other technical challenges faced were the multiple integrations with different devices, the requirement for intensive IT resources, issues with the mobile app in specific devices, necessity of SD cards that also collect the current location and timestamp so that the sensing devices are independent of a WiFi connection, etc.

Citizens (meaning potential users) were involved in the project from the stage of setting up the research question and designing the envisaged services, since the improvement of the platform and its components. They were able to send their requests for support or proposals for improvements through the project's email address and social media accounts. All issues were undergone a reality check, prioritized and, if crucial, inserted in the internal issue tracking system of DRAXIS and added to the workflow.

In the framework of the open mentality of hackAIR, the platform source code has been released on GitHub (https://github.com/hackair-project) and the collected datasets have been published on Zenodo (https://doi.org/10.5281/zenodo.1442608) so that other developers can build on top of it. Notably, the hackAIR platform collects more than 20,000 air quality measurements per day across Europe, and additionally discovers more than 1,500 sky-depicting images shared on Flickr under a Creative Commons license that are suitable for image-based air quality estimation. In addition, an API that enables the exchange of information with the hackAIR web and mobile app was released, accompanied by thorough API documentation. The air quality data that were collected from and created within hackAIR (collection from open air quality sources, measurements from hackAIR sensing devices and air quality estimations from sky photos) were anonymized and made available in Zenodo (https://doi.org/10.5281/zenodo.2222342) so that external researchers can further explore their usefulness and developers can deliver new services. Furthermore, the hackAIR partners provide open access to all the publishable project reports/public deliverables and the relevant peer-reviewed scientific publications through Zenodo and OpenAIRE.

The hackAIR solution was pilot tested in Germany and Norway, as planned, while pilot activities were organized also in other European countries due to the high interest of citizens all around Europe. More than 500 people participated in hackAIR workshops that had the goal to raise awareness about the project and get the people familiar with the hackAIR components. Around 3,000 people were actively involved in the project, used the hackAIR platform and provided their contributions; approximately 800 hackAIR sensors were set up by citizens and provided valuable measurements to the hackAIR community; almost 1,500 sky photos were uploaded to the hackAIR mobile app and used for air quality estimation; and more than 2,000 times hackAIR users reported how they feel the air quality through the hackAIR mobile app.

During the pilot implementation of hackAIR, wonderful user stories emerged, e.g. a user prepared a document with instructions on "how to make more sense of hackAIR sensor data", while another success story addresses an influencer who wanted to create a sensor network in Hessen, Germany on his own. All the success stories from participants in the hackAIR activities are listed in the project website (http://www.hackair.eu/news/) and will remain there after the project completion for inspiration for future initiatives.

Additional workshops were organized in the UK and Belgium in collaboration with the artist Ling Tan in the framework of the Vertigo residency programme. The aim of these workshops was to explore the correlation between citizens' subjective perceptions about air quality and measurements from the hackAIR sensors.

More information about the results from the hackAIR pilot activities can be found in the public deliverables D7.5: Pilot implementation report and D7.7: Final pilot evaluation report.

The Table below summarizes the measurable achievements of hackAIR.

*Table 1: hackAIR measurable achievements (4/1/2019)*

| | Success indicator | Unit | Target value | Achieved value |
|---|---|---|---|---|
| | O1: To develop collective sensing approaches for measuring air quality | | | |
| O1.1 | Environmental nodes on air quality to be indexed | Number | >10 | 17 |
| O1.2 | Environmental measurements to be indexed | Number | >10.000 | 100,700,000 total/ 20,000 per day |
| O1.3 | Public images from social media to be used | Number | 2,200 | 650,000 total usable/ 1,500 usable per day |
| O1.4 | User captured images to be used | Number | 800 | 1,413 |
| O1.5 | Low cost open hardware devices to be assembled | Number | 300 | 834 |
| | O2: To develop a methodology for synthesising heterogeneous air quality data collected in order to generate meaningful information, personalised to the requirements of citizens. | | | |
| O2.1 | Gridded fused data improves base maps and sensor data vs independent data | Normalized difference | <1 | Ca. 0.72 |
| O2.2 | Accuracy of data provided | % error | 25 | Ca. 25 |
| O2.3 | Time response of the personalisation services | Number | <10secs | 1.600s (average) |
| O2.4 | Semantically integrate heterogeneous content (environmental data, user preferences, profile) | Boolean | YES | Yes |
| | O3: To develop the hackAIR open platform for collecting, analyzing and sharing air quality measurements to community members through web and/or mobile phones | | | |
| O3.1 | Acceptance of hackAIR platform by end-users | % | 80 | 78% |
| O3.2 | Number of engaged individuals (in the platform) | Number | >300 | 834 expert users |
| | O4: To develop and deploy strategies for increasing engagement in monitoring air pollution and encouraging behaviour change | | | |

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|---|---|---|---|---|
| O4.1 | Number of engaged individuals (in the project activities) | Number | >8,000 | 8,406 |
| O4.2 | Reach of hackAIR messages to external communities and activists organizations | Number | >35 | 350 |
| | O5: To pilot test the hackAIR open platform in an operational environment, with the participation of user communities | | | |
| O5.1 | Basic users engaged in Germany | Number | 5,000 | 1,708 |
| O5.2 | Expert users engaged in Germany | Number | 200 | 374 |
| O5.3 | Basic users engaged in Norway | Number | 3,000 | 208 |
| O5.4 | Expert users engaged in Norway | Number | 100 | 130 |
| O5.5 | User satisfaction level<br>Web platform<br>Mobile application<br>Sensors<br>Overall mean score of the hackAIR tools | % | 90 | <br>68%<br>66%<br>69%<br>**67.6%** |
| O5.6 | Increased awareness (perceived) | % | 85 | 89% |
| | O6: To assess the usability and effectiveness of the hackAIR platform, and its social and environmental impact | | | |
| O6.1 | Effectiveness in promoting behavioural change | % | 80 | 71% |
| O6.2 | Usability of hackAIR platform<br>Web platform<br>Mobile application<br>Sensors<br>Overall mean score of the hackAIR tools | % | 80 | <br>69%<br>64%<br>82%<br>**71.6%** |
| | O7: To effectively disseminate the project activities and results, and ensure their sustainability and exploitation | | | |
| O7.1 | Visits to the project website per year | Number | 36,000 | 33,139 |
| O7.2 | User downloads of hackAIR Application | Number | 8,290 | 2,909 |
| O7.3 | Social media impressions | Number | 200,000 | 722,203 |
| O7.4 | Newsletter impressions | Number | 3,000 | 10,747 |
| O7.5 | Media- and online impressions | Number | 1,000,000 | 2,301,127 |
| O7.6 | NGOs and other civil society organizations informed about hackAIR | Number | 35 | 51 |
| O7.7 | NGOs and other civil society organizations adopting hackAIR platform | Number | 2 | 2 |
| O7.8 | Number of organised workshops | Number | 7-10 | 18 |
| O7.9 | Number of workshop participants | Number | 500 | 479 |
| O7.10 | Number of meetings of network of interest | Number | 4 | 5 |
| O7.11 | Total number of participants | Number | 100 | 107 |
| O7.12 | Number of external meetings with hackAIR representation | Number | 10 | 80 |
| O7.13 | Number of hackAIR stakeholders reached in project events and through the platform | Number | 150 | 6,622 (events only) |

Where:

- O1.1: Daily average number of sources of air quality data accessed every day (e.g. Luftdaten, OpenAQ, etc.)
- O1.2: Daily average number of air quality measurements used every day
- O2.1: The correlation between estimated values extracted from the data fusion model with observations from a set of air quality monitoring stations, given as the Pearson correlation coefficient, i.e. a number between 0 (no correlation) and 1 (perfect correlation). E.g. a correlation of 0.72.

- O2.2: The accuracy is measured as the fraction of correctly predicted hackAIR air quality index classes as compared to classes derived from observations acquired at air quality monitoring stations, given as a percentage. E.g. 75% correctly classified. (Note that in a previous version this was given as % error, which is just the opposite, i.e. 25%. However, I prefer to define accuracy as percent correctly classified.)
- Basic users: Those who have contributed sky photos to hackAIR without registering or those who have registered in the hackAIR platform to have access to air quality data.
- Expert users: Those who have set up a sensor that sent measurements to the hackAIR platform.

More or less all the above targets were reached except the planned number of basic users that were engaged and the envisioned number of the hackAIR mobile app downloads. The fact that the mobile app did not include all the proposed features from the very beginning of the project pilot implementation as it had to be updated to satisfy the user needs, might be an indicator for the low numbers of simple users. However, it is cumbersome to speculate about the reasons behind this, and since we do not know why people that heard about the project chose not to be engaged as basic users, we will not indulge in speculations.

# 3 Lessons learnt

The lessons learnt presented in this chapter were not deduced from a literature review, but from the experience of the hackAIR partners through the implementation of the project. A relevant questionnaire was distributed to partners by DRAXIS three months prior the end of the project, as a first attempt to aggregate best practices and overview the partners' perspectives. Later on in M34, all partners discussed these findings during a workshop within the 7th plenary project meeting in Thessaloniki. From this workshop, it was made clear that stakeholders with different roles (e.g. pilots, technical partners, etc.) may have totally different opinions. However, all these opinions should be reported to help future initiatives achieve more impact with less effort.

User requirements

- Successful projects are those that manage to cover their users' needs, at least partially. As a first step in the beginning of the project, you should focus your efforts on understanding the needs of your potential users and on collecting clear and concrete user requirements through co-creation activities. Obviously, it is not feasible to make them all happy, but try to match the user requirements with your initial project objectives, apply a reality check and prioritize the input you get.
- The needs of your potential participants and/or uncontrol factors may change during the project implementation. E.g. innovative technologies may emerge that are more popular among your target groups than the ones initially foreseen. You should have an agile approach and be prepared to adapt to this kind of changes.

User engagement

- It is, generally, easier to engage already interested user groups (e.g. environmental NGOs in the case of hackAIR), rather than people who are not even aware of the problem or deem it of low priority. If you want to be realistic, you should set low target for the user engagement as it is a challenging task.
- Try to establish synergies with relevant projects. There is the possibility that your project is not the first approach in this domain. Contact the initiators of other relevant projects and propose to join forces and share the collected data. In order for participants to use your solution instead of others it is important that you offer the most complete and advanced source of information.

- Physical workshops and in-person interaction are effective ways to engage and retain users. When organizing a physical workshop or a pilot activity with the participation of users, you should make them inclusive for different levels of skills in digital science and hardware assembly (if applicable).
- As above, users may have different literacy levels, and may not all feel that they are capable to contribute. Make sure that you hand over the necessary guidelines during each stage of the participation to enhance their sense of self-efficacy. Making participants feel part of a community will also be well received by them.
- In case that your project aims to educate participants or raise awareness on a specific topic, provide them with the necessary knowledge and the appropriate material, if applicable through a dedicated part in the platform.
- Pay attention and give time to select the colours, logos, and other graphic designs that will be used in your campaign.

Software & hardware development

- In case your project entails software development, try to keep it simple, with few functionalities that work perfectly. Be prepared to adjust it to new requirements during the project implementation.
- In case your project includes a platform as a citizen engagement tool, you should have in mind that people may be reluctant to join in if it requires registration and provision of personal information (even email address). Consider not requiring registration in the platform/ mobile application.
- In case you promised to offer your platform as open and reusable, you should also provide the means to give support in the different research tracks. This is even more important, when the project is not initiated by an academic partner, but by a societal stakeholder or a private company.
- In hackAIR, we initially thought that gamification would be a trigger for people to use the platform more frequently. However, the pilot implementation revealed that participants didn't want to compete with each other, but they had intrinsic motivation to contribute to the project for the common good. Gamification and leaderboards may stress the participants and lead to negative results. This conclusion refers only to the hackAIR project and may not be applicable for all kinds of citizen science projects.
- In your initial planning, allow enough time for internal testing until you go public. By delivering a non-functional "product" (either software or hardware), participants may get disappointed and abandon your project. However, this does not mean that you should wait until everything is working perfectly; you can deliver a "minimum viable product" early in the project and involve your target groups in the journey of finalizing it by clearly communicating that this is not the final version of your "product".
- In recent years, there is a growing interest from citizens on monitoring environmental conditions on their own by using easy-to-assemble hardware. Try to include hardware in your project, and use this aspect for promotional purposes. Sensors should be easy to couple with the created platform, while proper and clear instructions on how to use them should be provided to participants.
- If your project includes unofficial sensor measurements, try to validate the credibility of the data early in the project and properly communicate the results to the public. It is far better for your participants to know that the provided data are of low accuracy than not having any information about their credibility and imagining that these data totally represent the real conditions. This process will build trust among you and the participants.

User retention

- Ask for feedback from participants about how to improve the project. Make it easy for them to offer feedback, and accept it humbly and graciously.

- Don't underestimate the efforts you would need for user support and incorporation of their feedback. This effort is multiplied for projects that request from users to build hardware. Establish several channels through which users can directly contact you, answer as soon as you can to their requests/ proposals personally and not with automated messages, and don't forget to thank them for their interest and support. Keep in mind that this process requires a lot of time and patience!
- Quickly respond to participants about the validation results from experts of their contributions and the positive effect of their participation. Participants offer some of their free time voluntarily and by not receiving feedback about whether their contributions were of any use is quite disappointing. Try to process their contributions as fast as possible and at least let them know that you have received their contributions. This communication will make them connect more deeply and personally with the project and its objectives, and demonstrate the value of their involvement.
- Communicate regularly and repeatedly with participants about the progress of the project, its achievements and the milestones reached, and don't forget to give credits to them for these achievements. Keep the language used in this communication simple and friendly, and try to speak to participants' language.
- Identify the most active participants who can act as ambassadors, and share their stories with the public so that to inspire other people to contribute.
- Ensure transparency on how you process the data contributed by participants and how you handle personal data, if any. Especially when you use data available in social media be sure that you abide by the national, European and international rules.
- Special efforts have to be made to guarantee the quality of the obtained data and build trust with your participants. This can be reached through either controlling the quality of the data during their acquisition or subsequently after their acquisition by comparing them with reference data. The first approach requires the introduction into and training of data collection methods.
- When it comes to air pollution, people are generally more interested to know the air quality at a very local level, e.g. outside their home/ work/ school, etc. You should be very careful to communicate the severity of the problem according to the provided air quality scale, as people may misunderstand the message.
- Be careful what recommendations you provide to participants by considering all the possible health, social, and ethical aspects. For example, it may be better to exercise in a polluted environment than do not exercising at all. Thus, try not to be very strict.
- Involving independent experts in your project can raise the credibility of the used methodologies and the produced results.

Sustainability

- Concerning the sustainability of your project, consider the re-usage of the created data from other initiatives or the research community. Make them open and easily accessible accompanied with the appropriate instructions.
- Embrace multi-disciplinarity within the team that implements the project and leverage the potential.
- Don't forget to publicize the scientific results and made them available to the research community. The general objective of all the citizen science projects is to help the professional scientists.

# 4 Conclusion

Organizing and implementing a successful citizen science project is not an easy task, although there have been implemented numerous citizens science projects in the past that publicized recommendations on how to achieve high involvement of participants. hackAIR was one from several citizens science projects in the domain of air pollution, and it successfully managed to engage more than 8,000 citizens all around Europe in the wider project activities.

The current document summarizes some lessons learnt from the hackAIR partners during the project implementation and aims to assist future initiatives to achieve their goals with less effort by capitalizing the experience gained within hackAIR. The main conclusion of this document is that future citizen science projects should target first on groups of people who are already concerned about the problem that the project addresses. These people could act as ambassadors and motivate others to be actively involved in the project. All participants, however, should feel that their contributions are valuable, thus they should receive regular feedback about how their contributions help the community and researchers. Establishing synergies with relevant initiatives is another effective way to collect high volumes of data and save resources. For more information about the project outcomes, the public deliverables of hackAIR would be available in the project's website even after the end of the project.

# References


- ECSA, 2015. Ten principles of citizen science. https://ecsa.citizen-science.net/sites/default/files/ecsa_ten_principles_of_citizen_science.pdf
- D7.5: Pilot implementation report
- D7.7: Final pilot evaluation report