Citizen Science Starter Kit

Online Citizen Science Training Materials

Deliverable 3.3 I V3 - October 2023

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part of EUTOPIA European University

EUTOPIA
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Co-funded by
the European Union

This project has received funding from the European Union's Horizon 2020 Framework programme under grant agreement No 101017419 EUROPIA-TRAIN

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Preface

The citizen science starter kit provides information to researchers who are new to citizen science. It helps you to initiate or support a citizen science research (project), regardless of the scientific discipline. It is a how-to guide for beginners, a foundation course, with the most essential information to get started.

The starter kit consists of different modules:

- **Module 1 – Start to learn about citizen science.** This first module reflects upon the different terms and characteristics used to describe citizen science. The benefits of citizen science research are listed, and the diversity of the field is illustrated with case studies in all scientific branches and disciplines.
- **Module 2 – Determine if citizen science is right for your research.** Before you initiate a citizen science project, you should reflect on whether it is suitable for your research. This module provides some reflective questions as well as decision frameworks to figure out the suitability of a citizen science approach.
- **Module 3 – Crucial design factors for successful citizen science.** This module presents crucial design factors for planning and developing your citizen science research (project).
- **Module 4 – Getting started with citizen science.** This interactive module helps you to design your citizen science research (project). Templates, guidelines and checklists are provided.

The objective of this starter kit

The citizen science starter kit shares **information** about what citizen science is (and what citizen science is not) through definitions, guidelines and tips & tricks. Furthermore, it aims to raise **awareness** about the opportunities of citizen science through providing key examples of citizen science projects. As such, the starter kit also encourages researchers to start with citizen science, and to consider the citizen science approach in (project) proposals. Lastly, the starter kit also supports **reflection and creative thinking**. Through the interactive materials, researchers should be able to make critical design choices for running a citizen science research (project).

Target audience

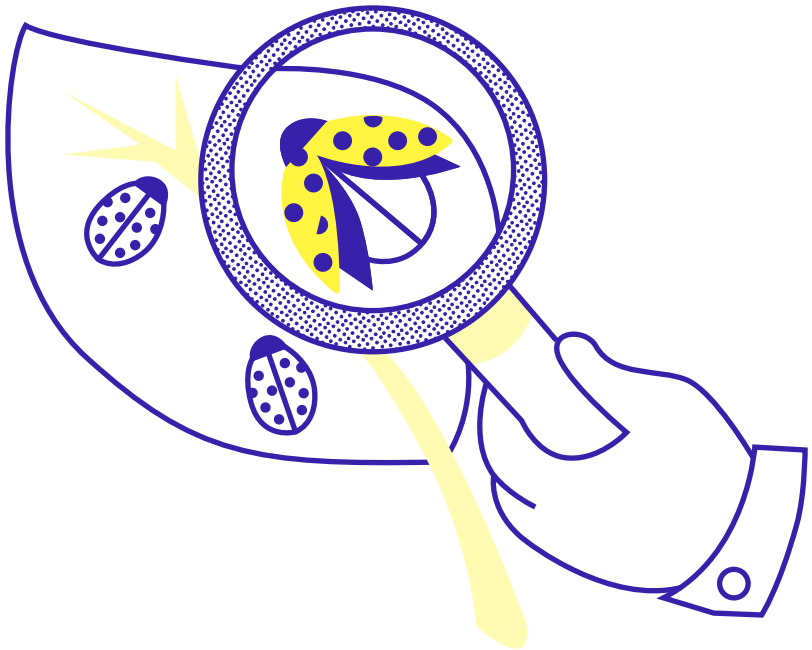
The citizen science starter kit targets researchers who are not yet familiar with citizen science. Maybe you have already heard about citizen science, but you do not know exactly what it entails or how to start with it. Therefore, the citizen science starter kit is entry level, and does not require any previous knowledge or skills in citizen science.

The starter kit targets researchers in any research discipline. Anyone is able to apply the starter kit in their domain. To enable this, the starter kit highlights examples from various scientific branches.

Attribution

The citizen science starter kit is a deliverable of the EUTOPIA TRAIN project, and the writing has been coordinated by the Vrije Universiteit Brussel. The first edition was published in June 2022, and the current version will be published in October 2023. We would like to thank all the contributors for their inputs.

If you would like to cite the materials, please use the following reference: Veeckman, C., Van den Bogaert, L., Keersmaekers, F., Verbrugge, K. & Livémont, E. (2023). The Citizen Science Starter Kit. Getting started with citizen science. Published by the Vrije Universiteit Brussel. https://doi.org/10.5281/zenodo.10119036



Module 1

Start to learn about citizen science

The first module of this training kit reflects on the different definitions of citizen science found in literature, as well as its main characteristics. To elucidate what citizen science is (not), practical examples are given throughout the module.

Furthermore, the benefits of citizen science are listed, both for science and society. At the end of the module, the diversity of citizen science is described through practical case studies in various scientific branches and disciplines.

Goal: At the end of this module, you are able to define the main characteristics of citizen science and have a basic understanding about what citizen science is (not).

1

What is citizen science?

Citizen science, also known as community science, crowd science, civic science, crowdsourcing, volunteer monitoring, volunteered geographic information, is often used as an umbrella term to describe a wide range of participatory activities that involve lay people ('citizens') in the scientific process.

In the last decades, societal and technological changes have increasingly allowed citizens to contribute to science, leading to a rapid growth of citizen science in all scientific branches and disciplines. Furthermore, citizen science is also receiving increasing attention from policymakers who are launching specific funding programmes on the local, national and international levels.

The increased interest brought along several definitions, with different terms used to refer to citizen science activities. As such, there is not one single exhaustive definition of what citizen science is, nor a set of specific quality criteria[1]. In this training kit and in accordance with the Flemish Knowledge Centre on Citizen Science in Flanders (abbreviated, Scivil), we use the following definition of citizen science:

"Citizen science involves scientific research conducted in whole or in part by non-scientists (citizens), often in collaboration with, or under the guidance of professional scientists."

(Cambridge English Dictionary)[2]

Citizen science thus refers to research conducted (at least in part) by citizen scientists; citizens who contribute to research in their free time. Citizen scientists often – but not always – collaborate with, or are supervised by domain experts, academics or governments.

Scivil – Bringing science and society closely together

Scivil is the knowledge centre for citizen science in Flanders. Scivil was founded with funding from the Flemish government (Department of Economy, Science and Innovation) in early 2019 to unite, support and inform scientists, citizens, policymakers and organisations about citizen science. Scivil provides workshops and lectures on citizen science and provides advice to current and future citizen science projects. They also develop guidebooks and manuals and set up thematic working groups on citizen science.

More information: https://www.scivil.be/en

The rise of citizen science: a brief history

The term citizen science has multiple origins. It was first mentioned in the 1990s by Rick Bonney[3] (US, ornithologist) and Alan Irwin[4] (UK, sociologist). Their perspectives are being presented as two meanings or strands on citizen science. The first strand, from Irwin, stresses the democratic potential of citizen science. It emphasizes the responsibility of science to society, whereby participants can participate in science in a multitude of ways. At the other end of the spectrum is the narrow usage of the term by Bonney, defining citizen science as an approach for cost-effective data collection. In this latter perspective, large-volume observations are gathered to serve the objectives of the scientific enterprise, rather than the co-creation of knowledge with society.

However, the concept of citizen science is nothing new in the history of scientific research. If we look at the history of modern science, you can also label the first amateur scientists as 'citizen scientists'. Amateur scientists have been performing research in their free time from their living rooms without being part of any formal academic institution, or without being formally recognized as a scientist. For instance, Caroline Herschel discovered in 1786 a comet, named 'Caroline', by studying the skies on her own[5]. Years later, she became the first female scientist in England at the Royal Astronomy Society.

If you would like to read more on the historical background of citizen science, you can access this MOOC, or this resource of the Citizen Science Track project.

In an article by Muki Haklay[6], who is widely recognized for his work in citizen science, a list of definitions of citizen science is provided. Depending on the context of application, the definitions of citizen science seem to vary. Some of the definitions have an instrumental focus, while other definitions are rather descriptive or have a normative focus. This multiplicity of definitions should not be regarded negatively. It is important that differences are supported, and they are essential for the further development of citizen science. The risk of one single definition is that a variety of activities is excluded, or that certain practices would not fit into the specific field of research anymore.

Summary

While there is no single definition of citizen science, it will always entail public participation in scientific research. Feel free to choose a definition that best suits the context of your research.

1.1

ECSA characteristics and principles

Amongst the multiplicity of definitions, the European Citizen Science Association (ECSA) provides guidance to practitioners with regard to fundamental principles which are expected of a good citizen science project. ECSA is the central hub for citizen science initiatives in Europe and aims to support the exploration of how citizen science can be understood and practiced.

In 2015, the association published the "Ten principles of citizen science", which cover the commitments between project organisers and participants on handling of data, ethics and open science, level of engagement in science, etc. It is an often cited and used resource for defining and implementing citizen science. To further address the ambiguity in the field, ECSA and partners of the EU-Citizen.Science project have set up a working group which developed a set of characteristics of citizen science (based on the above principles). These characteristics describe the range of activities that can or cannot be included within a citizen science activity. They recommend reading their document in conjunction with the principles since the characteristics provide concrete demonstrations of some of the principles.

10 principles of citizen science[7]

1. **Citizen science projects actively involve citizens in scientific endeavour that generates new knowledge or understanding.** Citizens may act as contributors, collaborators, or as project leader and have a meaningful role in the project.
2. **Citizen science projects have a genuine science outcome.** For example, answering a research question or informing conservation action, management decisions or environmental policy.
3. **Both the professional scientists and the citizen scientists benefit from taking part.** Benefits may include the publication of research outputs, learning opportunities, personal enjoyment, social benefits, satisfaction through contributing to scientific evidence e.g. to address local, national and international issues, and through that, the potential to influence policy.
4. **Citizen scientists may, if they wish, participate in multiple stages of the scientific process.** This may include developing the research question, designing the method, gathering and analysing data, and communicating the results.
5. **Citizen scientists receive feedback from the project.** For example, how their data are being used and what the research, policy or societal outcomes are.
6. **Citizen scientists are acknowledged in project results and publications.**
7. **Citizen science programmes are evaluated for their scientific output, data quality, participant experience and wider societal or policy impact.**
8. **The leaders of citizen science projects take into consideration legal and ethical issues surrounding copyright, intellectual property, data sharing agreements, confidentiality, attribution, and the environmental impact of any activities.**
9. **Citizen science is considered a research approach like any other, with limitations and biases that should be considered and controlled for.** However unlike traditional research approaches, citizen science provides opportunity for greater public engagement and democratisation of science.
10. **Citizen science project data and meta-data are made publicly available and where possible, results are published in an open access format.** Data sharing may occur during or after the project, unless there are security or privacy concerns that prevent this.

To further explain what citizen science is (not), we clarify some additional aspects which often lead to a misunderstanding:

- Citizen science is not equal to disseminating science information. In citizen science research, the public actively participates in the research and is not merely the target of science communication. The public is actively engaged in the scientific process, whereby science communicators still ensure that the whole process and outcomes are communicated in an accessible way to the participants.
- Citizen science is not equal to science 'about' citizens but rather refers to scientific research undertaken 'with' or 'by' citizens. In some disciplines, such as the medical and social sciences, it is common that citizens themselves, their behaviours, challenges, needs, etc. are under examination. In these disciplines, it is possible that people who take part in such projects can be both subjects and participants at the same time[8].
- The term 'citizen scientist' does not refer to a scientist whose work is characterized by a sense of responsibility to serve the best interests of the wider community. This definition was used by the New Scientist magazine in 1979 but is nowadays rarely being used.
- Citizen science is not driven by commercial gain. If the main aim of the activity is driven by commercial gains, e.g. being paid for providing data, then it is not considered citizen science.

Further reading:

- ECSA platform https://ecsa.citizen-science.net/
- We recommend exploring the EU-Citizen.Science platform of the European Citizen Science Association (ECSA), where you can find an extensive database of resources about citizen science, as well as the latest projects and updates in the field:
  - **ECSA resources** https://eu-citizen.science/resources
  - **ECSA projects** https://eu-citizen.science/projects
- Research work on 'Characteristics of Citizen Science'.
- Links towards other trainings and handbook resources:
  - Michael Pocock, Daniel Chapman, Lucy Sheppard & Helen Roy, Choosing and Using Citizen Science. (Centre for Ecology & Hydrology, 2014)
  - Lisa Pettibone, Katrin Vohland et al., Citizen science for all. A guide for citizen science practitioners. (Buerger schaffen Wissen, 2016)
  - John Tweddle, Lucy Robinson, Michael Pocock & Helen Roy, Guide to Citizen Science. Developing, implementing and evaluating citizen science to study biodiversity and the environment in the UK. (UK-EOF, 2012)

Time to reflect – Share your thoughts and opinions:

- One of the most popular citizen science projects in Flanders is Curieuzeneuzen ('Curious Noses'). With 20,000 participants, it was one of the largest projects organised on air quality. Are you able to demonstrate that this is indeed a citizen science activity by applying the ten principles to this case?
- Two important delineators in the discussion on what citizen science is (not), are the level of engagement within a project and a genuine research outcome. Based on these criteria, can you think of an example of a project which is not defined as citizen science?
- Is this citizen science or not?[9]

1. On FixMyStreet, citizens can report incidents in public space (trash, damaged sidewalks, broken traffic lights, etc.) to their city or town. Volunteers often upload photos and observations to an application or online platform. Is this citizen science or not?
2. The Town-City Monitor is a policy monitor that assesses the broad environment of a city or town using about 300 indicators or sets of figures. More than 100 of these come from a large-scale three-yearly citizen survey. In all 300 Flemish cities and towns, citizens are invited to fill in a questionnaire to evaluate how they experience living in their city or town. Is this citizen science or not?
3. Sarah is a social worker. Her work is emotionally demanding and she has discovered that watching birds improves her wellbeing. Being new to birding, she uses a bird observation recording app. It allows her to maintain a list of birds that she observes. Observations are shared as open data and contribute to ornithological research and environmental management.[10] Is this citizen science or not?
4. Stefano is a high school student. During his visit to the local museum, he spends time at an interactive exhibit that shows him the different mammal species in the area, which were photographed by camera traps. The exhibit invites visitors to identify them, giving a score at the end. It was designed by the museum's experts and data from interactions is not stored or used beyond session duration and visitor numbers.[11] Is this citizen science or not?
5. Ella is a web designer and interested in a healthy lifestyle and technology. She uses the TopFit smartwatch to collect biometric data throughout the day to monitor an reach personal health and fitness goals. She shares this data with the TopFit community and sometimes participates in TopFit challenges. She pays a subscription fee and receives personalized dashboards, notifications and tips. She often follows this advice and has changes her routines.[12] Is this citizen science or not?

1.2

Terminology matters

Terminology matters, also in citizen science[13]. The words that we use for what we observe or what we describe can matter greatly for people. Language is a sensitizing concept. Therefore, it is recommended to communicate clearly about the main terminology used, in accordance with the objectives of your research. Explain why you opt for certain terms and discuss how someone feels affected by them. For instance, which terms are you using to describe the citizen science activities, and what do you call people involved in the research?

In this training kit, we opt for the term *'citizen scientists'* or *'citizens'* to refer to people who participate in a citizen science project. These may be individuals, groups of citizens, or networks and organisations. On the other hand, we refer to *'researchers'* as professional scientists who work in academia or in a research-performing organisation who coordinate or participate in a citizen science project as a stakeholder. Activities can also be organised by public bodies (e.g. cities or towns) and non-governmental organisations (e.g. charities).

The below figure, based on an illustration in the article of Eitzel et al. (2017), gives an overview of the commonly used names to describe people who participate in citizen science. Every term is explained and interpreted in a different (negative) way:

Summary

Think carefully about the terminology used in your citizen science research. You can explain the choice of wording and you can question your target audience to know how they feel affected by it. As such, you can determine the right terminology.

*Illustration based on W*hat to call people involved in citizen science projects. Illustrated examples by *Eitzel et al. (2017).*

2

Benefits of citizen science

Citizen science can yield a variety of benefits and outcomes. They can occur at the individual level or at the larger science–society level. Individual benefits mainly occur for researchers and citizens, while societal benefits can occur for the broader community, and society as a whole. From the individual participant's perspective benefits can be related to, for instance, increased topical knowledge, while on societal level this can be related to political and environmental types of benefits.

	Science	**Society**
Individual level	**Benefits for researchers** *E.g. increased research capacity*	**Benefits for citizen scientists** *E.g. topical knowledge*
Societal level	**Benefits for science** *E.g. more societally relevant research*	**Benefits for society** *E.g. impact on policies and institutions*

Table 1: Benefits of citizen science at the individual and societal level.

It is important to note that this typology is not exhaustive and that benefits might be mutually inclusive. Furthermore, the types of benefits that can be generated will largely depend on the objectives and design of your research.

The main benefits for science and society are listed in detail in the following sections, with additional reading tips.

2.1

Benefits for science

Citizen science can yield individual benefits and outcomes for researchers in the following ways:

- **Increased research capacity**: One of the main reasons why researchers opt for citizen science is the increase in research capacity for data collection and analysis. The work done by citizens does not have to be performed by the researchers themselves, and this is particularly interesting when you want to set up a long-term monitoring programme with a large spatial and temporal coverage, or when a vast amount of data needs to be collected or analysed. The main advantage is thus the shared workload, up to the point where (some of) the research would not be able to take place without the tasks performed by the citizen scientists.
- **Newly acquired data and info**: Through the participation of citizens in your research, you can add lay, local and traditional knowledge to scientific knowledge. Citizen science can thereby not only increase the amount of research data but can also result in more qualitative and diverse data and information that would otherwise have been very difficult to collect (e.g. in private gardens). You can gain access to localized knowledge (e.g. access to certain citizen communities), allowing you to investigate a topic more deeply.
- **More innovative research**: By democratizing science processes and diversifying actors in the research, new research methods can arise, research strategies can be improved, and new discoveries can be made. This can lead to the production of new scientific knowledge and more innovative, or creative research.

On a broader societal level, citizen science can yield the following benefits:

- **More societally relevant research:** By including citizens in science, the research can better account for citizens' needs. New research questions can be identified that otherwise would have been neglected. This can ensure that the research is more societally relevant and publicly accepted.
- **Bridging the gap between reseearchers and citizens:** Citizen science equals collaboration. When citizens are involved in science, better mutual understanding can be created between citizens and researchers. Overall, this can develop mutual trust and confidence between scientists and the public.
- **Diversity in science:** When engaging with different actors (inter- or transdisciplinary), more diverse viewpoints and expertise can be included in the research process. This can lead towards more balanced points of view.

	Benefits for science
Individual level (researchers)	• Increased research capacity • Newly acquired data and information • More innovative research
Societal level	• More societally relevant research • Bridging the gap between researchers and science • Diversity in science

Table 2: Summary of benefits for science (based on Goudeseune, et al. (2020)[14], Hecker et al., (2019)[15])

2.2

Benefits for society

Citizen science can also yield individual benefits and outcomes for citizens in the following ways:

- **Scientific literacy:** By participating in science activities, citizens can become more scientifically literate[16]. They gain insights into science in general, with the opportunity to learn specific skills and abilities (e.g. critical thinking skills, understanding basic analytical measurements, etc.).
- **Topical knowledge**: Being involved in citizen science activities can not only increase knowledge about science in general, but also about the research topic at hand. Through training and experiential learning, citizen scientists may expand their knowledge of the issue central to the project. This is particularly the case when the project invests in educational efforts.
- **Behaviour change**: In turn, increased knowledge can lead towards changes in attitudes and behaviours. This is especially true for projects related to environmental topics, whereby an increased awareness and support for certain themes can occur (e.g. air quality, mobility, etc.). Furthermore, such raised awareness is known to correlate with environmental stewardship, meaning citizens might grow a stronger "sense of ownership" for their natural environment and community. This can lead towards environmental activism, whereby citizens are empowered to be active stewards[17]. Alternatively, it can lead towards increased political participation or more healthy behaviours, depending on the topic of your research.

More broadly, citizen science can also generate benefits on the political and environmental level:

- **Political benefits:** The data collected in citizen science projects can help to inform, decide and follow up on policies, which can make them more societally and politically relevant. Citizen science can thereby provide an evidence base for data-driven policymaking. Moreover, by involving citizens in decision-making processes, such as in the monitoring or evaluation of a policy, it can result in greater acceptance and support for important policy themes. The data gathered in citizen science can eventually also impact on policies and institutions.
- **Environmental benefits:** Citizen science projects can also lead towards actions for improved environments. For instance, citizen science research can help to identify polluters or exotic threatened species, to monitor biodiversity with specific conservation actions, or to reinforce tougher environmental policies, laws or regulations with evidence-based data. Sometimes, citizen science projects also have a cross-over with the implementation of nature-based solutions, e.g. tree planting programmes.

	Benefits for society
Individual level (citizens)	• Scientific literacy • Topical knowledge • Behavioural change (including stewardship and civic participation)
Societal level	**Political benefits:** • Data-driven policymaking • Societal relevancy of policy • Impact on policies and institutions **Environmental benefits:** • Improved environments

Table 3: Categories of benefits (based on Den Broeder et al., 2016[18], Hecker et al., (2019)[19], Veeckman et al. (2021)[20], Walker et al. (2021)[21])

Further reading:

- To gain more insights into the outcomes of your project, you can set up a summative evaluation of the project's benefits for its participating citizens and society as a whole. For executing this type of evaluation, you can check the following online learning course of the Centre of Social Innovation on the eu-citizen.science platform.
- Understanding what citizens gain from engaging in citizen science can help in recruiting and retaining participants. This article from Fan & Chen (2020) matches motivational theories with benefits of citizen science participation.
- The Cornell Lab of Ornithology has developed different tools for measuring outcomes and evaluating citizen science projects. A specific toolkit is available for measuring citizen outcomes.
- Citizen science can yield many more advantages for citizens at the individual level, such as increased social capital[22], place-making[23] and self-efficacy[24].

3

The citizen science landscape

Citizen science projects can be organised within many scientific branches and disciplines. To showcase the diversity, this chapter describes citizen science practices in the natural sciences, formal sciences, medicine & health, arts & humanities, and the social sciences. Some scientific disciplines already have a long-standing tradition with citizen science, while others are just at the beginning.

Specific case studies are provided in each research field. At the end of the module, a list of additional sources is provided with inspiring examples of citizen science across Europe.

3.1

Citizen science in the natural sciences

The natural sciences combine the study of living and non-living systems, with specific disciplines in the physical sciences (e.g. chemistry, astronomy, etc.) and life sciences (e.g. zoology, environmental sciences, etc.). The history of the natural sciences is closely related to citizen science[25]. Many amateur scientists have shaped and grounded the natural sciences by observing environmental phenomena and recording their findings. These amateur scientists outlined the beginnings of the professionalization of science. Through this development, the natural sciences are the most commonly practised scientific discipline in citizen science.

The natural sciences easily lend themselves to citizen science approaches through the usage of sensors and/or by organizing large-scale monitoring campaigns across space and time (cf. Module 2). These monitoring projects mainly invite citizens to collect data by counting species, such as birds or butterflies. The best-known examples of citizen science in Flanders perform(ed) in the natural sciences are focused on biodiversity (e.g. Mijn Tuinlab), mobility (e.g. Telraam) and air quality (e.g. Curious Noses,).

The data collected in these citizen science projects can have a significant potential to support public authorities in policymaking. In support of this, the European Commission is advocating a more systematic integration of citizen science into environment-related policy (e.g. the European Green Deal and the United Nations Sustainable Development Goals). In this report you can read more about the opportunities and benefits of using citizen science for environmental monitoring, with good practices and obstacles for further uptake.

Case study Animals in the wild – looking for tracks in the city

Green and open spaces play an important role in the quality of life in cities. With increasing population density in cities, these areas and the habitats for urban wildlife are increasingly coming under pressure. Through the project "StadtWildTiere" in Germany, Switzerland and Austria, residents from urban areas are asked to share observations via photographic material of animals or their tracks on an online platform. Volunteers can also rent a camera trap to make observations. StadtWildTiere works with ambassadors, where each ambassador is responsible for observations of one square kilometre of the city. The ambassadors are asked to take regular walks and to talk to residents of their area. A specific training to recognize animal tracks is offered by the institute StadtNatur.

The data are used for scientific studies by a team of biologists and ecologists from the StadtNatur team.

Read more about this project: https://stadtwildtiere.ch/

3.2

Citizen science in the formal sciences

In contrast to the natural sciences, the formal sciences do not have a long-standing tradition of collaborating with citizen scientists. Formal science is a branch of science studying disciplines concerned with formal systems such as logic, mathematics, computer science, artificial intelligence (AI), game theory, etc. The adoption of citizen science approaches into this field is just in its infancy, but it is expected that new technological developments, especially in the field of AI, will provide momentum.

Examples of mathematical projects that have adopted aspects of citizen science can be found in collective problem solving and distributed computing[26]. Projects in collective problem solving focus on online collaboration between mathematicians to solve difficult mathematical problems (e.g. the Polymath project), while the latter projects engage citizens who offer their time and devices. Citizen scientists are requested to install and download a tool on their computer. The application monitors the computer for spare computing power and that power is used to solve a mathematical problem. This type of project does not involve the citizens on a personal level, as they only need to install a programme and donate their CPU time (e.g. The Great Internet Mersenne Prime Search).

The usage of AI in citizen science enables cross-over with other scientific disciplines, with citizen science applications using machine learning techniques for biodiversity monitoring for instance. AI is currently used in citizen science to assist or replace humans in completing tasks (e.g. classifying images for species detection), influencing human behaviour (e.g. through personalization and behavioural segmentation), and for improved insights (e.g. training of algorithms using citizen science data)[27]. It is likely that new applications of AI in citizen science will appear in the future.

Case study – Eye For Diabetes

Citizen scientists in the Eye For Diabetes project examine the retinal images of diabetes patients online via the Zooniverse platform. They mark signs of diabetic retinopathy on retinal images, a disorder which can lead to blindness. The catalogue of images can then be used to teach an algorithm to recognise the disorder, paving the way for screening by artificial intelligence. As such, the citizen scientists are helping to build a reference database of annotated images, which can be used to train an AI software to recognise diabetic retinopathy in future. This project exemplifies the cross-over between the formal sciences and health research.

More information about this project:
https://www.oogvoordiabetes.be/

3.3

Citizen science in medicine & health

Health science has lagged far behind in adopting a citizen-based approach, although the number of projects in this domain is increasing nowadays. This increased interest is fed by various trends, including increased health literacy among the general population and the emergence of sensors and self-tracking devices[28]. Citizen science in health, or citizen health science, focuses on questions raised by citizens with varying levels of scientific participation with scientists. Often citizens collect data on their own health and act of their own accord to change outcomes.

The development of citizen health science faces certain challenges related to leadership norms. Traditionally, health science and medicine have been in the hands of a few, while participatory science in health comes with shared initiation and leadership. Furthermore, there can be potential liabilities, such as inherent biases that one carries in relation to one's own interests, challenges and choices or issues with validity of the results. Despite these concerns, there is also a great potential for innovation. Citizen science in healthcare can ensure that the research is better tailored to what patients want, resulting in a higher probability of relevant scientific knowledge for a broader range of stakeholders.

If you are interested in citizen health science, there is an ECSA working group called 'Citizen Science 4 Health'. Its main objectives are to create a community of stakeholders on citizen science for health, to develop and disseminate tools, methods, ethical frameworks and training material, and to enhance the visibility and potential of citizen science in the health domain.

Case study: Isala

Isala is a citizen science project that wants to get a better understanding of the female microbiome using state-of-the-art DNA technology. The project is organised by an interdisciplinary team of researchers at the University of Antwerp. In March 2020, a call was launched in Belgium to find 200 people willing to take a swab from their vaginas, skin and saliva. In total, more than 3,300 women reacted and received a testing kit. With the help of bioinformatics, researchers studied the genetic code of the bacteria. Results revealed that 80% of the participants had a vaginal microbiome dominated by lactic acid bacteria; these bacteria are associated with a healthy vagina. The participants received the outcomes of the study and are further invited for a second phase whereby the research data will be combined with extensive questionnaires to exert factors that impact the health of the vagina.

Read more about this project: https://isala.be/

3.4

Citizen science in the arts & humanities

Citizen science in the humanities, or citizen humanities, encompasses fields such as languages, literature, history, philosophy and art. The primary object of investigation is human culture, and it favours methods of interpretation, critical thinking and analysis[29]. Typologies in the citizen humanities range from on-site projects to digital-only projects, whereby citizens are invited to participate in data collection or data analysis of artefacts. These artefacts can be physical or digital, either collected or provided by archives, repositories, galleries or museums, or provided by the citizens themselves. Citizens often perform tasks that include curating, transcribing, or annotating artefacts.

Many projects have been taking place in the arts and humanities. They are often coordinated by universities, museums and archives. In terms of science communication, museums and archives are increasingly incorporating experimental zones and labs, where volunteers can participate or contribute to exhibitions.

If you are interested in citizen science in the arts and humanities, you can have a further look at this training module of the Parthenos project. It helps you recognize and define approaches for incorporating citizen science into your research project.

Case study: Enrich your view of Bruges

In the citizen science project 'Verrijk de kijk op Brugge' (Enrich your view of Bruges), participants help to describe images from the city archives, the public library and 'Musea Brugge'. Participants are asked to look at the images and describe what they see. Which people can you identify? What buildings do you recognize? Do you recognize Bruges or a borough? Participants complete an instructional form and then transmit the information to the registrars. The finalized information is shared through this website.

3.5

Citizen science in the social sciences

Citizen science in the social sciences, or citizen social science, has been developing in meaning and prevalence over the past decade. Broadly, we define citizen social science as an approach that involves participants in a social sciences research project[30], whereby they implement tasks which are traditionally implemented by scientists. These projects have a specific focus on social or behavioural aspects, or they take place within an interdisciplinary synergy (e.g. natural sciences and social sciences). A synergy with the social sciences helps to understand the human dimension in the study, enriches the scientific research and helps to boost public participation[31].

A crucial distinction should be made between citizen social science and the participation of volunteers in a research study by giving an interview, joining a focus group or responding to a survey. These latter are not referred to as citizen science as citizens are the research object and are not actively participating in the research process. Within citizen social science, participants enrich the research process by asking questions or choosing research methods that might not have occurred to professional scientists. Furthermore, they can make the research study more refreshing and inclusive by drawing on their social and cultural capital[32]. Citizen social scientists might have connections with relevant communities or places of interest, which professional scientists might not have considered or have access to.

If you are interested in citizen social science, the CoACT project looks into participatory research forms which are directly driven by citizens and their social concerns.

Case study: Health connects Amsterdam–Slotermeer

In 2014 and 2015, a group of Slotermeer residents attended a training to become Health Ambassadors. These residents interviewed their neighbours about how healthy they think Slotermeer is in terms of litter, exercise and sports, child-friendliness, greenery in the neighbourhood, ambience, traffic and transportation, etc. They collected this information from local residents and, in turn, gave them advice on certain topics, such as moisture problems at home. The ambassadors learned how to interview, gained additional knowledge, and started to think more positively about the health of Slotermeer. Moreover, the interviewers came into contact with people outside their direct network. This way, talking about health served a connecting function, crossing cultural differences. The results were presented during a health festival for local residents and other interested parties. They will also be used to complement existing scientific insights and to better align policy with practice. A total of 221 interviews were conducted by 22 ambassadors.

Read more about this project:
http://www.kijkeengezondewijk.nl;https://www.rivm.nl/gezonde-leefomgeving/kijk-gezonde-wijk-watsap-project

3.6

More examples of citizen science

- Agilas (archaeology)
- Airbezen (air quality)
- CurieuzeNeuzen (air quality research 2018)
- CurieuzeNeuzen in de Tuin (garden research, heat stress)
- De Grote Schelpenteldag (biodiversity)
- D-Noses (measuring scents)
- DoeDat platform (various domains)
- Luftdaten (air quality)
- MamaMito (genealogy & genetics)
- Mijn Tuinlab (garden research, health, biodiversity, sustainability)
- Paleontologica Belgica (palaeontology)
- Radio Meteor Zoo (meteorology)
- Researching Age-Friendly Cities (health and wellbeing)
- S.O.S. Antwerpen (social injustice in mortality)
- Straatpoëzie.nl (literature research)
- Straatvinken (traffic counts)
- Telraam (traffic counts)
- VeleHanden (heritage)
- Verrijk de kijk op Brugge (artistic research)
- Waarnemingen.be (nature observations)
- Waterland vzw (healthy rivers)

3.7

Other websites

The following websites may offer further inspiration on examples of citizen science in Belgium:

- http://www.iedereenwetenschapper.be/: This website lists citizen science projects in Belgium and the Netherlands. You can also advertise your project here to find citizens.
- https://www.scivil.be/projecten: This website lists citizen science projects funded by project calls of the Department of Economy, Science and Innovation in Flanders.

Other international examples:

- The Zooniverse platform lists projects in the sciences, humanities, and more (e.g. arts, biology, climate, language, literature, etc.). The Zooniverse is a collaboration between institutions from the United Kingdom and the United States.
- Inspiring examples of citizen science in Austria can be found here (German/English). This website is managed by the Citizen Science Network in Austria (CSNA). You can search by different domains (weather, mobility, culture, language, etc.) and by type of tasks.
- Citizen science in health care organised by ZonMw (independent health care research organization in the Netherlands).
- SciStarter is a popular US-based Citizen Science portal with more than 3,000 projects, searchable by location, topic, age level, etc. SciStarter hosts an active community of close to 100,000 registered citizen scientists and millions of additional site visitors. https://scistarter.org

Module 2

Determine if citizen science is right for your research

Before you choose a citizen science approach, it is recommended that you reflect on whether it is the right method for your research (project). Citizen science does not fit for all research topics. In certain circumstances, more conventional science methods or other types of public engagement mechanisms might just do the trick or might be even better suited.

This module helps you to reflect and determine whether citizen science is the right method for your research (project). Several situations are described which lead to beneficial outcomes, with helpful examples in the various scientific disciplines.

Goal: At the end of the module, you are able to assess whether citizen science is suitable for your research (project) and decide on the right type of citizen science research. The different types of citizen science approaches are explained at the end of the module.

1

When is a citizen science approach appropriate?

Citizen science may yield many benefits, both scientifically and socially. However, when you are new to citizen science it is hard to decide whether it is the right approach for your research objectives. In the right circumstances, citizen science may be very beneficial. In other circumstances, other ways to engage the public may be more appropriate.

In this chapter, several decision-making factors are described to help you decide whether citizen science is a viable option. Before you start your project, we advise you to reflect upon the following elements in order to make a well-founded decision:

Readiness level towards public engagement	The importance of engagement
Transdisciplinary research	The spatial and temporal scale
The amount of data that need to be analysed	The complexity of the data protocol
Promotion of scientific learning	The available project budget

Table 4: Main elements for assessing the suitability of a citizen science approach.

In Module 4, a fill-in template is provided for assessing these elements for your specific research (project).

1.1

Readiness level towards public engagement

Nowadays, there is a trend in academia to invest in public engagement mechanisms. More and more projects are getting support for not only opening up research results to society, but also for genuinely engaging the public in research projects. However, little research has been performed on understanding potential organisational shifts within academic culture regarding public engagement. What are the attitudes towards pursuing public engagement in the university, in specific departments and of individual researchers? Is it practically achievable, and which processes need to change to support it? Which capacities are needed, what are potential obstacles?

Applying citizen science might require a change in working habits, operational processes, and in hierarchies. The extent of this necessity is dependent on the type of citizen science project you are going to implement (cf. Typologies of citizen science projects). Furthermore, different challenges might be encountered than those in more conventional scientific methods. Specific obstacles regarding the design and organisation of the project might be experienced (e.g. the mobilisation of participants and sustaining engagement) but there are also data-related challenges (e.g. data quality)[33].

Therefore, before you start with citizen science, take a step back to reflect: "What is your mindset towards public participation in scientific research, and do you have the capacities to organise it?" To help you assess your readiness level, you can fill in our readiness test in Module 4.

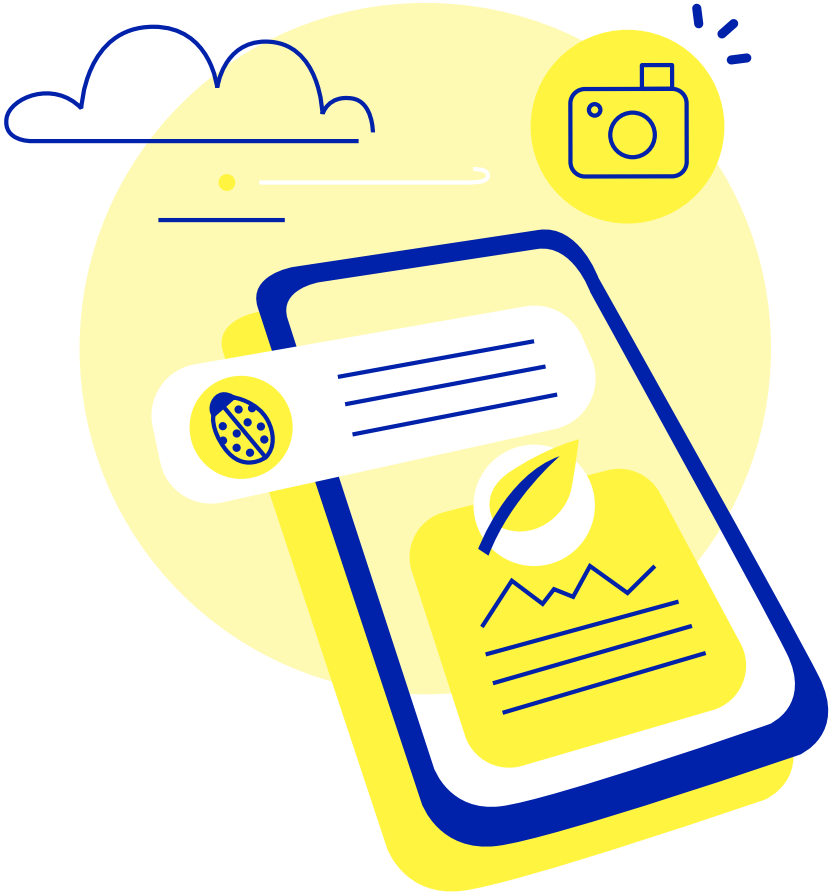
If the tests reveal that you need further support for applying a citizen science approach, then the Citizen Science Contact Point can help you. Look out for our various series of workshops and specific one-to-one support services. Module 3 also provides more concrete information related to data management and team capacities.

Summary

Certain attitudes and new working practices will most probably have to come into place when practising citizen science. Before you consider citizen science, it is advised that you self-reflect on your readiness level. To what extent can you be transparent, open and deliberative about your research? Which capacities are needed to perform the research? Fill in the readiness test (Cf. Module 4) and feel free to contact the Citizen Science Contact Point if you need further support on this.

Reading tips:

- This literature review by Weingart et al. describes the main trends on public engagement, and how it shifted from 'public understanding of science' to 'public engagement with science'.
- Have you already heard about the term 'RRI'? RRI, or Responsible Research and Innovation, is a policy-driven discourse that emerged from the European Commission. It aims to foster the design of inclusive and sustainable research and innovation, with an emphasis on co-creation. If you would like to learn more about this discourse, you can read this handbook.
- The Eurobarometer of May 2021 questioned citizens' opinions on inclusion in science and technology. The study revealed that six out of ten think that involving non-scientists in research ensures that science and technology will better respond to the needs, values and expectations of society.
- Citizen science is one of the eight ambitions of the EU's Open Science policy. The aim is to engage and involve citizens and civil society organisations in co-design and co-creation processes so as to promote responsible research and innovation.
- Read a qualitative study performed in the UK about a shift in attitudes on public engagement in health research here.



1.2

The importance of engagement

In addition to your readiness level, you should also consider how important engagement is for your research (project) and how you can bring it into practice. Participants can be engaged in the different phases of the research cycle. The table below illustrates a few potential tasks that can be performed by participants, grouped per research phase:

Formulate a research question	Develop or choose a method	Collect data	Analyse data	Report & disseminate
• Submitting an idea • Expressing concerns • Participating in ideation sessions • Crowdsourcing challenges • ….	• Co-creating citizen science tools • Becoming an interviewer • Developing a measurement device • Defining a survey protocol • ….	• Photographing • Counting • Observing • Using sensors • ….	• Annotating • Transcribing • Interpreting • Calculating • ….	• Proposing new directions for research • Co-authoring a publication • Speaking at a public event • Becoming a project ambassador • …..

Table 5: Examples of potential citizen science activities performed along the research cycle

Apart from activities in the scientific research process, citizens can also fulfil tasks related to the research design and project management, such as developing training materials, establishing a network of participants, organizing communication and support mechanisms, holding meetings and events, etc. This is often the case in research (projects) with a high level of citizen involvement (cf. Typologies of citizen science projects).

Regardless of the activity participants are performing, they should be engaged in an active, meaningful way[34]. They are involved in the research as co-designers and implementers of research tasks, and not as a research object. Participants are also no longer the target of science communication, but actively engage in the scientific process. As such, research in which citizens participate as respondents in tests or interviews, complete surveys or attend focus groups is *not* called citizen science. Rather, when citizens are taking an active role in organizing or conducting these tests, interviews, surveys or focus groups, then we do call it citizen science.

Citizen science should not be confused with participation. Many participatory projects actively involve citizens in policy, innovation and other topics. The co-creative methods used in these projects can also be applied in citizen science. However, if these methods do not provide data from which scientific conclusions can be drawn, it is not citizen science. For instance, if these methods are more focused on informing about a particular issue, then we speak of science communication.

If we take these two elements into account, i.e. active, meaningful engagement and participation for purposeful scientific research, it may well be that citizen science does not fit your problem statement. In that case, more conventional methods might be better suited.

Summary

The active participation and engagement of citizens are important components of citizen science. However, engaging citizens just for the sake of reaching participation is not citizen science. Citizens should be actively engaged in the research and the engagement practices should clearly serve a scientific goal.

Reading tips:

- If you would like to learn more about engagement strategies and tools, you can consult this practical guide to communication and engagement in citizen science.
- From a theoretical perspective, science communication models and theories lie on a spectrum from more scientific-oriented to public-centred. You can read more about the deficit model, the dialogue model and the participatory model (of which citizen science is an example) in this publication.
- This publication outlines different models and impacts of public participation in scientific research and discusses it from the perspective of different fields and traditions.

Time to reflect – share your thoughts and opinions:

- What is the importance of citizen engagement in your research (project)?
- Which type of activities can citizens perform?
- Do you think that one-way communication might be sufficient for your research?
- Do you think you can get more out of your research if you encourage people to contribute to certain research activities?
- Do you think your research would be possible without the contribution of citizens? If yes, what is the added value of the citizen science approach?

1.3

Transdisciplinary research

Citizen science is highly suited to creating transdisciplinary connections by constituting a research team from different scientific disciplines and different faculties. Interdisciplinary environments challenge researchers to work together to reach a common goal, to find a common vocabulary and share knowledge. At the European level, Research & Development programmes are calling for higher interdisciplinarity to come up with quicker and more effective solutions to wicked problems[35].

Furthermore, citizen science is also highly suitable for collaboration with stakeholders from outside academia. In citizen science projects, we often see collaboration among the following actors[36]:

- **Civil society**: citizens, action groups, civic associations, and other (voluntary) societies where participants can be recruited through a membership base
- **Knowledge institutions**: research and science institutions, schools, (vocational) universities and educational associations (science museums, libraries)
- **Governments**: towns and cities, authorities on the local level and other public organisations
- **Industry**: private companies with expertise in types of sensors, building platforms, legal or judicial advice, communication and media for instance
- **Funders**: Local, national or European institutions that provide funding or launch grant calls for citizen science

By stimulating transdisciplinary dialogue, citizen science can help in facilitating a shared understanding among stakeholders and the research team. It can also help in making the research more locally relevant, and in providing a holistic perspective of the issues at hand.

Summary

Citizen science is well suited to inter- and transdisciplinary collaboration, particularly if you want to study a phenomenon from different angles. You can collaborate with stakeholders outside of academia, which can make your research more locally relevant and at the same time supported by a wide range of stakeholders.

Reading tips:

- Read more about transdisciplinary research here, written by Christian Pohl (2011).
- The social sciences and humanities (SSH) are gaining more acknowledgement within interdisciplinary citizen science projects. This discipline helps to learn about the social dimensions of the research, and to provide a framework for engagement. Read more about the inclusion of SSH in this article from Tauginienė et al. (2020).
- This article from Hidalgo et al. (2021) stresses the communicative and dialogical translation work that is required in interdisciplinary teams.
- You can read more about how to set up collaborations and partnerships with local government in Chapter 5 of the handbook 'Citizen Science roadmap for local government', developed by Scivil (in Dutch).

1.4

The spatial and temporal scale

Citizen science is highly suitable if you need to collect or analyse data across large spatial scales and/or over longer periods of time. It is one of the main reasons why people decide to perform citizen science: teamwork makes the dream work. By engaging a large group of citizen scientists at the same time, the research can be more effectively accomplished. The time and costs needed for the same job performed by more conventional science methods would be considerably greater[37].

For this reason, we see many citizen science projects in the field of environmental monitoring. Citizen science allows to collect data at a fast pace, and at places that otherwise would not have been accessible (e.g. in private gardens, or at remote locations). Since many of these projects are repeated over time, it also allows species and ecosystem dynamics related to environmental changes to be studied. In some cases, the citizen science monitoring programmes are even able to collectively produce finer grained and more expansive datasets than official measurement programmes. In this regard, debates are currently occurring concerning whether citizen science data is of sufficient quality to use for policymaking[38].

Tips:

- Official air quality monitoring stations are rather sparse in Flanders (Belgium). Read how the Curious Noses monitoring programme improved the air quality models in Flanders with air quality data on street level thanks to the participation of 20,000 citizens here.
- These applications are used for environmental monitoring purposes with a large spatial and temporal scale: iNaturalist, eBird and Map of Life.
- On national level in Belgium, we have the database https://waarnemingen.be/ by Natuurpunt and Natagora for observations in nature. For monitoring the weather, there is the database of WOW-BE (Weather Observations in Belgium).

Summary

Citizen science is highly suitable if your study needs to collect data across a large spatial area for a long period of time. By engaging many volunteers simultaneously, it is cost-effective to obtain the data.

1.5

The amount of data that need to be analysed

Citizen science is also highly suitable when large amounts of data need to be analysed. For instance, when you need to analyse a large historical database with manuscripts, satellite images, or webcam photos. If you can make these data available, citizen scientists can help in speeding up the analysis process.

For processing large volumes of data, we often turn to computers to help us out. However, in some cases human ability is still superior. Humans are still delivering better results for sorting tasks, pattern recognition and analysing audio and images. In this regard, citizen science is meeting artificial intelligence nowadays[39,40]. Citizen scientists are helping to train deep learning algorithms based on the classifications performed. Once fully trained, the software applications will carry out automated classifications. Online platforms that can help you with the analysis process are The Zooniverse Platform, doedat.be and velehanden.nl.

Be aware that for processing large volumes of data, the motivation of participants might decrease when tasks are dull and very repetitive in nature. In this regard, gamification and fun elements can help. For instance, the Zooniverse platform offers a space to save, share and discuss objects users have found. Users can post in the 'Talk picture' sharing function and discuss examples that could be mistaken for artwork[41]. Other

potential game elements are badges, listing top contributors of the week, unlocking levels, group missions, etc. These elements work very well for younger age groups and extrinsically-driven participants[42].

Case study: The Zooniverse platform

The Zooniverse is the world's largest and most popular citizen science platform for data analysis. Around 1.6 million users are registered who are contributing to research projects in all scientific disciplines. With the help of the volunteers, researchers can analyse their information more quickly and accurately than would otherwise be possible. Via the Zooniverse builder you can create your own powerful interface for data analysis.

More information: https://www.zooniverse.org/

Lastly, if a large amount of data needs to be analysed, you also need to reflect on the complexity of the protocol. For analysing a large amount of data, you will hope to engage large numbers of citizens who are able to finish the task in a fast and simple way.

Summary

You might consider citizen science when you need to analyse a large amount of data or images, satellite images or photos from webcams for instance. If you can make the data openly available, an online web interface can support the analysis process.

1.6

The complexity of the data protocol

The complexity of the data protocol can is another decision-making factor. The data protocol is the way participants are going to collect data in your project. The main rule of thumb is to keep this as easy as possible. The easier participants can collect data, the more likely you will collect data of high quality. If the data protocol is too difficult, participants might drop out quickly, you might exclude certain groups, or end up with inaccurate data measurements.

Case study: The data protocol of the Eye for Diabetes project.

The Eye for Diabetes project engaged citizen scientists for annotating retinal images in order to train an algorithm for early disease detection of diabetic retinopathy. In this project, the Zooniverse platform was used to annotate a dataset of retinal images. Participants had to surf to the Zooniverse portal, where they had to register in order to keep a record of their contributions. A short tutorial explained them how to complete the tasks. Participants were first introduced to simple tasks and, over time, they progressed to more advanced tasks. Overall, it was decided that each image should be annotated by at least ten different participants in order to identify outliers.

Website: https://www.oogvoordiabetes.be/

A straightforward protocol will also help you to engage a large audience. If a lot of data need to be collected or analysed, it is recommended that participants can follow a standardised approach. The protocol should ensure, to the extent possible, that participants are able to collect or analyse the data independently. This is certainly the case when participants collect data at private or dispersed locations.

More complex protocols are also possible in citizen science projects. However, you need to be aware that only a particular type of profile, most often with an expert background, can participate (e.g. naturalists, hobbyists, medical professions, etc.).

How-to guides and/or training sessions can support citizens in learning how to apply the protocol. It often helps when the protocol is explained in small and simple tasks. Furthermore, a test session can be organised with friendly users to evaluate the quality of the protocol. These insights can help you to ameliorate the comprehensibility of the task descriptions, and to check the consistency of the data. Test sessions can also help to build in extra validation options in order to ensure that the data is correctly collected or analysed.

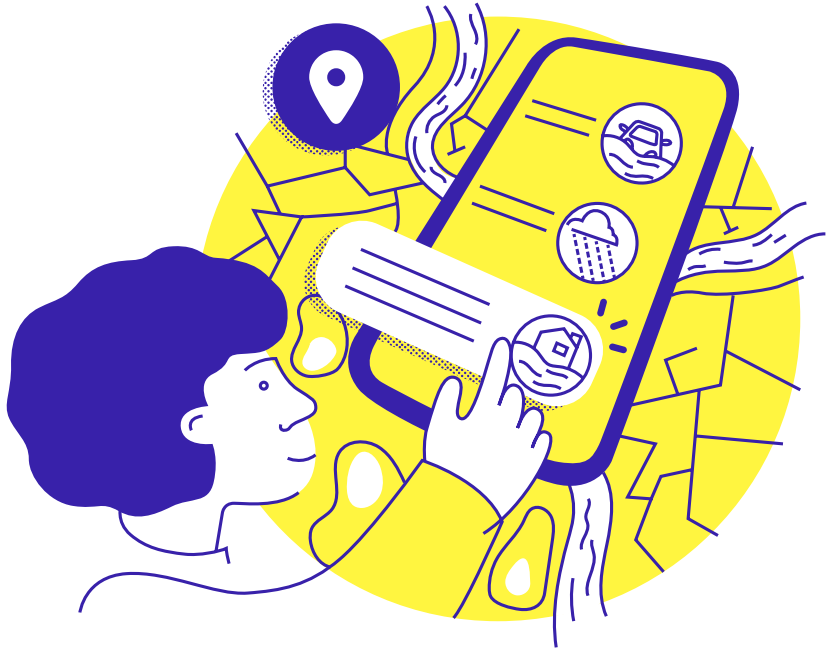
In Module 4, a template is provided to help you to reflect about the design choices of the data protocol.

Tips:

- Be aware that certain groups might be excluded based on the design choices of your data protocol. Not everyone has access to the Internet or a smartphone or has the appropriate digital skills for your project. If you would like to make your project accessible to everyone, be sure to provide an alternative with the right support.
- Get to know your participating citizens and match their skills and knowledge with your data protocol. For instance, to what extent are citizens familiar with using sensors? Do they have previous experience with annotating images? Small tasks can be outlined for beginners, while more experienced citizens can follow more advanced protocols. Over time, beginners can level up to more advanced tasks.

Summary

The main rule of thumb is to keep the data protocol as easy as possible. A more complex data protocol is also suitable for citizen science but will only work for a particular profile of participants. A successful protocol design for citizens is one that keeps them well practised and motivated to gather consistent data. In Module 4 a template is provided to reflect about the design choices of a data protocol.



Further reading:

- This guidebook from Pocock et al. (2014) includes a decision framework for citizen science in the field of biomonitoring, and includes several questions on the data protocol.
- The data charter for citizen science (available in Dutch and English) can help you with further questions on data quality. This data charter is published by Scivil, the Flemish Knowledge Centre on Citizen Science, in collaboration with Digitaal Vlaanderen.
- The online MOOC of the WeObserve project teaches you to capture and analyse data and use the findings to take action. The MOOC is particularly relevant for citizen science projects and citizen observatories focusing on environmental monitoring.

1.7

Promotion of scientific learning

If you would like to bring science to the classroom, you can choose to set up a citizen science project. Through citizen science, pupils and students can take part in science through fun and hands-on activities. In these projects, researchers and school/student communities are working in tandem. On the one hand, observations can be collected that advance real science and, on the other hand, curiosity and learning are sparked.

Engaging youngsters, students and teachers in a citizen science project can help to promote scientific literacy. Pupils and students can connect with scientific knowledge and be inspired about the work of scientists. They learn how to ask scientific questions, run experiments and can draw evidence-based solutions. Researchers can also train teachers in scientific inquiry and research methodologies. This ensures that the activities are meaningful for all, and that teachers can support the activities to guarantee good quality data.

Different citizen science approaches for promoting scientific learning can be applied. Firstly, you can choose to design your project specifically for school education, whereby the pupils or students are invited to participate as part of their school curriculum. In specific cases, citizen science also has the potential to activate Science, Technology, Engineering and Mathematics (STEM) learning[43]. A second approach is that you extend the scope of your project with (in)formal education

and classroom practices, by developing specific information packages. Formal learning generally occurs in the classroom with clear learning objectives, whereas informal learning takes place outside the classroom, or after school, in places like museums nature clubs, fablabs, etc.

If you would like to implement citizen science in formal education, then the following tips can help you:

- Decide in advance which age group is suited to your project
- Define the learning objectives and attainment levels and mention these specifically in your communication to the teachers. With this information, they can determine whether your project fits their lessons
- Adapt your activities to the school context (take into account holidays, school hours, ...)
- If possible, collaborate and co-design the materials together with a teacher, or consult a teacher from time to time about your approach so that it can be well aligned with the classroom context

Further reading:

- Scivil provides a handbook on 'Citizen science in the classroom'. You can consult it as a pdf or through the online e-class.
- If you would like to read more about citizen science in the classroom, you can check the materials developed by the BRITEC project. They offer different guidebooks and also a MOOC on citizen science education.
- This article from Roche et al. (2020) talks about the challenges and opportunities of citizen science projects in formal and informal learning environments.
- There is a European Citizen Science Association (ECSA) working group on learning and education in citizen science, which helps to develop the informal learning and educational aspects in citizen science projects. Learn more about this working group here, or read their book chapter with main highlights here.
- You can consult this article from Philips et al. (2018) if you would like to measure the individual learning outcomes of your research (project).

Summary

If you would like to promote science learning among school communities, then you can consider a citizen science approach. Citizen science is a great opportunity for pupils, students and teachers to immerse themselves in science activities.

1.8

The available project budget

Citizen science can be a cost-effective way to gather a vast amount of data in a short period of time. With the help of citizen scientists, scientific information can be collected on scales and at resolutions that would have not been possible for individual researchers or whole research teams. It is however a misunderstanding that a citizen science project is free of charge. There are several costs, different to regular research projects, that you need to consider.

Firstly, there are **personnel costs** related to the recruitment and engagement of citizen scientists. Participants should be looked for, engaged and motivated to remain in the project. Time should also be allocated to the training of participants. Trainings can be organised in person or online, with supervision also during the data collection. Trainings and the establishment of a data protocol are vital for ensuring data quality. Personnel costs will also be dedicated to communication and awareness raising activities. Communication is a vital aspect in a citizen science project. Ideally, your project has a science communicator who makes sure that messages, research results included, are communicated in an accessible and understandable manner.

Furthermore, there are **material costs**, but this does not always have to be the case. Material costs can be very diverse, ranging from measurement kits to a project website. These costs can be limited if the project can rely on open-source materials.

These types of costs can be a potential burden if you want to start with a project. There is a potential risk of not being able to recruit enough participants, in keeping them motivated, or in having sufficient materials. Furthermore, if the budget is limited or only short term, you also run the risk that your research project will be discontinued quickly after its ending.

Tips for finding financial resources:

- Look for sponsors or raise funds from a wide audience through crowdfunding.
- Integrate a citizen science approach in proposals of regular funding streams. The granting of subsidies for this type of research is not limited to specific citizen science calls.
- Local governments often do not have subsidy lines for citizen science projects. Instead, localized citizen science initiatives can often rely on support if there is a link with existing grant lines in connected social domains (e.g. mobility, circular economy, health, etc.).
- Participants can cover a portion of the costs. If you are transparent about the costs and if the intrinsic motivation to participate is high, participants are often willing to contribute financially.
- Build a partnership around your project. That way, not only the efforts but also the costs can be shared.
- Save costs by using open-source software and freely available applications. Developing equipment by yourself is very time-consuming and costly.

Summary

It is a misunderstanding that citizen science is a cheap (or even cost-free) approach to collecting data. Although data can be collected in a cost-effective manner, there are several costs that you need to consider which are different from conventional science. Investment needs to occur for costs related to recruitment, engagement, communication and training of participants. If your project is low on budget or builds on short-term 'flashpoint funding', then it is advised that you look for (additional) financial resources to make your project plan more solid and durable.

Time to reflect – share your thoughts and opinions:

- This article from Scivil outlines seven successful strategies when applying for citizen science funding. What is your experience this far in applying for citizen science funding?
- How will you guarantee that research involving citizen scientists does not discontinue quickly after the project ending?

Further reading:

- This thesis of Fauver (2016) researches the cost savings of citizen science projects by comparing three projects with their professional equivalent.
- This article from Alfonso et al. (2022) examines the value of citizen-generated data, with a methodology to compare the value with existing environmental observations and the evolution of their costs in time.
- This article from Encarnação et al. (2021) presents the costs incurred for monitoring marine invasive species. It is presented as a low-cost monitoring campaign, for which the strategy can be easily replicated.
- This opinion piece by Dr. Paul Drachman is about economic considerations of citizen science projects. The attention paid to economic factors in citizen science is not particularly high, or not the decisive factor, in comparison with other values such as education and the scientific significance of the project.

2

Typologies of citizen science projects

Once you have decided that citizen science is the right approach for your research, the next step is to reflect upon the type of citizen science project. In scientific literature, there are several typologies which classify citizen science projects. We discuss typologies based on the degree of participation and the primary project goal.

2.1

The degree of participation

The most commonly used typology by citizen science practitioners is based on the different degrees to which participants are involved in the scientific process. The models below stem from the broader field of Public Participation in Scientific Research (PPSR), which covers different forms of citizen involvement in research.

Based on the degree of participation, Shirk et al. categorize projects into five models[44]:

Type	Description	Example
Contractual	Citizens ask professional scientists to conduct a specific scientific investigation. Citizens can exert control over the research agenda and the resulting knowledge produced. However, further participation in the remainder of the research process is limited.	The 'Wetenschapswinkel' (Science Shop) is a project is a project of the VUB, the University of Antwerp and the KU Leuven. It is an example of a contractual project, whereby not-for-profit organisations and civic organisations can raise a question, a concern or an idea for a research project. The Science Shop matches the input with students and promotors.
Contributory*	The project is designed by scientists and citizens are generally invited to gather data (over wide geographic areas and/or over long spans of time). The researchers decide upon the research focus and the protocol for data collection.	In the citizen science project Vespa-Watch, members of the public are asked to look out for Asian hornets (and their nests). This exotic wasp species is a threat to the native bee. When they spot the insect, citizens upload a photo and the GPS coordinates to the project website. Research scientists working at Ghent University use the data to map out the dispersal of the species. The citizen scientists merely supply the data.

Collaborative*	The project is designed by scientists, and citizens can take part in different phases of the research process. Apart from data collection, they can also participate in the project design, the analysis, and dissemination of findings.	In 2014 the project AIRbezen in Antwerp involved a large group of citizens who collected data (they submitted the leaves of a strawberry plant, which they had left out on the window ledge, for an analysis of the air quality). Research scientists at the University of Antwerp collaborated in the first phase of the project with volunteers from the Stadslab 2050 group. Together they brainstormed how the study would be done and what it should be called. This small group of volunteers also helped with the plant distribution and communication.
Co-created*	The project is collaboratively designed by scientists and citizens. The research question or issue is defined by the public. All the research steps leading on from this are taken by the citizens in consultation with the researchers.	In Antwerp, a citizens' observatory was set up under the European Ground Truth 2.0 project. Scientists, policymakers and citizens regularly meet to consider study areas and solutions for environment-related challenges like air pollution, drought, flooding, lack of greenery, and heat.
Collegial contributions	This project is designed by amateur scientists, or hobbyists, such as amateur astronomers, archaeologists and taxonomists, who often work on their own. They conduct research independently.	Amateur scientists or hobbyists are often working independently, or are connected with fablabs, or hobby clubs for instance.

Table 6: Five project models based on the degree of participation by Shirk et al. (2012). Projects indicated with an * are also defined by Bonney et al. (2009)[45]

The table above lists the projects from a low to a higher level of engagement, with the contractual and collegial models at the far boundaries of the PPSR spectrum. In the literature, you can find similar models according to the degree of participation but with different labels. For instance, the typology of Haklay is also commonly used for categorizing citizen science projects based on the level of participation and engagement[46]:

Type	Description	Example
Crowd-sourcing	Citizens only offer resources in terms of time and devices (e.g. volunteered computing and citizens as sensor carriers). The cognitive engagement is minimal.	The World Community Grid projects make use of the computers of thousands of volunteers. You create an account on the website and download a tool to your computer. The application monitors your computer for spare computing power and that power is used to conduct virtual experiments. The citizen scientists play a passive role but are notified about the research being done.
Distributed intelligence	Citizens collect data or carry out a simple interpretation activity or help to categorise the research material.	Citizen scientists in the Oog voor Diabetes (Eye For Diabetes) project examine the retinal images of diabetes patients online. They note any signs of diabetic retinopathy, a disorder which can lead to blindness. The catalogue of images can then be used to teach an algorithm to recog- nise the disorder, paving the way for screening by artificial intelligence.
Participatory science	Citizens are engaged at the start of the project. They help define the problem, collect data, and then help the scientists analyse the material. The professional scientist still has a high level of control over the analysis and interpretation.	The idea for CurieuzeNeuzen 2016, in which members of the public measure the air quality in Antwerp, arose in the Ringland community group. Scientists and the Flemish Environment Agency (VMM) then became involved in the research.
Extreme citizen science	Researchers and citizens define the various steps in the research process together. However, the role of the scientist is confined to that of facilitator. This opens up the possibility of citizen science without professional scientists, in which the whole process is carried out by the citizens.	Using the so-called flitsfiets (flashbike), a DIY bike, the action group 30Max records speeding offences in the centre of Antwerp. The group aims to use the data to show that the speed limit is rarely observed and hopes to force the introduction of measures. The action group itself came up with the idea for the flashbike. Researchers from the imec City of Things helped find the technology and data to make it work.

Table 7: Four project models based on participation and engagement in citizen science projects defined by Haklay (2013).

It is important to mention that these typologies are not normative rankings[47]. Not every project needs to engage citizens in every stage of the scientific process. The level of engagement has a lot to do with the research objectives you have in mind. Aspiring to a higher level of engagement is thus not necessary, although it will lead to different types of outcomes for the public. Likewise, engaging citizens more deeply in the research process does not mean that the collected data will be less scientifically interesting.

Tips:

- Think carefully about your research design and choose the type of model with the end goal you have in mind. Will a given degree of citizen participation be sufficient to achieve a desired outcome?
- You do not have to apply one degree of participation in your research (project); you can also facilitate multiple levels. Citizens will inherently create their own individualized experience, regardless of the predominant model of participation in your research. As such, you might have a core group of participating citizens who are engaged in all stages of the research process, while the majority only contributes with data collection or creation.
- You can modify your project design along the project lifetime. This is particularly useful when you notice that your participating citizens are changing their interests and motivations to participate in the research (project). This will support sustained, or continued, citizen participation in the project.

2.2

The project goal

A different way of categorizing citizen science projects is by focusing on the primary target goal of the project. Wiggens and Crowston clustered projects based on the explicit goals mentioned in the project materials, and found five different types of citizen science projects[48]:

Type	Description	Example
Action	These projects are organised by the public (e.g. grassroots organisations), and not conceived by scientists. They focus on local concerns and use scientific research as a tool to support the civic agenda. Professional scientists are engaged as consultants. The projects are often small-scale and strongly localized.	In 2015, the project 'ADEM' measured the air quality in Ghent through the usage of low-cost sensors placed on a bike. The project was organised by a group of interested citizens and the organisation Timelab.
Conservation	These projects are mostly initiated by researchers or by governmental actors. They are primarily focused on data collection for resource management, and promoting stewardship and awareness. They are often long-term and large-scale.	Through the project 'Smart Waterland', the City of Roeselare is trying to collect precipitation data via a fine-grained network of pluviometers with the help of citizens. The data are assembled via a platform (Internet of Things) in order to be able to approach water management in the city in a smarter way. The information collected via various pluviometers can be used immediately to steer the water system or to intervene and start emergency services for approximately 2 hours. This system can help Roeselare to respond to climate change.

Investigation	These projects are mostly initiated by academics or by non-profit organisations. They focus on scientific research goals, and provide educational materials to the public. They often operate on a larger physical scale.	The citizen science project 'Stiemerlab' started from the premise that citizens of Genk and local organisations can actively contribute to assess and address the water quality issues of the Stiemervallei. The project actively involved citizens, for example by training them as citizen scientists to collect data on the water quality in the Stiemerbeek using sensors. The project ran from 2020 till 2022, and was initiated by LUCA School of Arts in cooperation with VITO, UHasselt (Centre for Environmental Sciences), the City of Genk and Vlaamse Milieumaatschappij (VMM).
Virtual	These projects are initiated by academics. Their primary goal is similar to investigation projects, but all the project activities are ICT-mediated. The projects make use of custom web platforms or open-source technologies.	The Galaxy Zoo project is a crowdsourced astronomy project which invited citizens to assist in the classification of a large number of Galaxies. Galaxy Zoo is part of the online platform Zooniverse. There have been 15 different campaigns since 2017.
Education	These projects are organised top-down and mostly involve multiple types of partner organisations. Their primary goal is focusing on education and outreach. The projects can be further subdivided into formal and informal learning.	The Airbezen project in 2015 focused on the involvement of schools in East-Flanders (Belgium) to measure the air quality with the help of strawberry plants. An educational package was provided for primary schools, and science events were organised for secondary schools. Secondary schools were given the opportunity to analyse the samples themselves in the lab.

Clustering projects based on their goals is to run the risk of thinking simplistically. Many citizen science projects have multiple objectives, often balancing between scientific and educational goals. Projects can originate at the university or at research centres, in the public realm, or both. The taxonomies provided can be useful as a starting point to help you reflect on the type of citizen science research. However, in reality, these taxonomies might blur, with different crossovers in features. Therefore, we recommend reflecting on these typologies as a starting point, from which you then implement the right customized design for your research (project).

Time to reflect – share your thoughts and opinions:

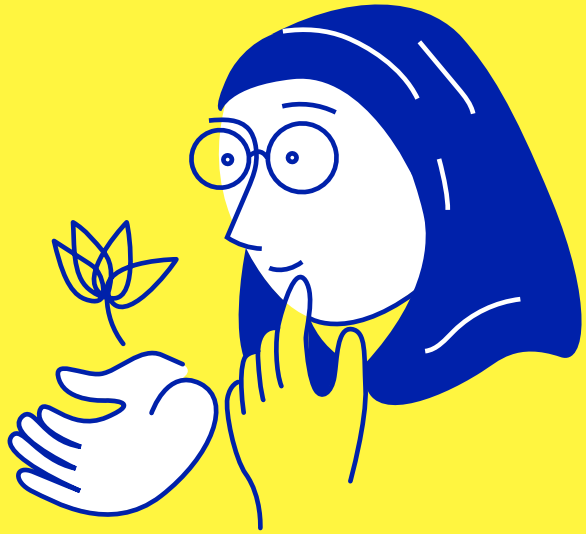
- Which model does your research (project) resemble? What is or are the different degrees of citizen participation?
- If it were feasible, would you set up your research exclusively online? Why (not)?
- Extreme citizen science projects challenge the scientific culture in the sense that it requires scientists to engage deeply with social and ethical aspects of their work. This potential change process is framed by Haklay with the following phrase: '*the emphasis is not on the citizen as a scientist, but on the scientist as a citizen*'[49]. What is your opinion on this?

Further reading:

- Based on the former mentioned typologies of Bonney et al., Shirk et al., and Wiggens and Crowston, this article from Schäfer & Kieslinger (2016) integrates all typologies into one quadrant based on the locus of knowledge creation and the focus of the project activities.
- The typology of van Noordwijk et al. (2021) is focused on distinct participating citizen groups and their motivations to participate. The article describes four different types of projects: place-based community projects, captive learning projects, interest group projects and mass participation projects.
- To further grasp the variety of citizen science inquiries, Fan & Chen (2020) look at it from a political angle and define models related to how citizenship is built into the research (project). Four models are described in their article, namely 'Cosmopolitan Community knowledge', 'Science, State and Citizen', 'Democracy and Justice' and the fourth type 'Civic commons and techno-social infrastructures'.

Module 3

Crucial design factors for citizen science



Module 3 describes some crucial design factors for conducting successful citizen science research. These design factors relate to specific processes and mechanisms that can either drive or hinder the success of citizen science. The definition of what 'successful' citizen science is will vary from context to context. Success might be defined by the amount of gathered data and the number of research publications, or by the established social impact. Success is thus context-specific and will be in line with the objectives and goals of the research project.

The following design factors are described in this module: (1) A communication and feedback culture, (2) Motivational strategies to participate, (3) Mechanisms for ensuring data quality, and (4) Usage of citizen science platforms for data management.

Goal: At the end of this module, you are able to understand crucial design factors and have some general guidance at hand for starting your citizen science research project.

1

A communication and feedback culture

A crucial design factor in citizen science is the set-up and maintenance of a communication and feedback culture, both internally and externally[50]. Communication is a vital aspect of citizen science, and it is a necessary part in every step of the research process. Communication activities will be needed for recruiting and engaging citizen scientists, increasing the visibility of your research project, informing about the project's results and outcomes, etc. It takes good practice to communicate effectively, and you may not underestimate the amount of time that you will spend communicating with your target audiences. Ideally, your research project will have a community manager, a science communicator and a science trainer who can look after these activities:

- The **community manager** is the main point of contact for your citizen scientists if they have any questions. In some research projects, it will be necessary to have a forum or a central support service. The community manager is proactive in sharing information and news, and in finding the right answer to questions from citizens. It is not necessary to be available 24 hours per day, but desirable to provide an answer within a respectable amount of time (within 1 to 3 days). Furthermore, the community manager can also motivate participating citizens to help each other out[51]. As such, participating citizens can also become ambassadors for your research project.
- The **science communicator** ensures that scientific content is easily understandable and accessible to a broad audience. The science communicator proofreads the materials and checks if it adheres to inclusive communication principles.
- The **science trainer** makes sure that citizen scientists are properly trained for collecting or analysing data by providing manuals or support on the ground.

There are many factors in place that affect the success of communication activities in a citizen science project[52]. Overall, it is recommended that a communication plan for your research project is developed in advance. A communication plan is a detailed description of all communication steps by which you plan to engage your target audiences. It lists the steps in chronological order, and links them with the relevant target audiences, the tools and channels, and the aims you hope to achieve. A communication plan should be written in the planning phase of your research project, and adjusted throughout the entire project. It is important to allocate a budget for this, as it will help you to set priorities; do you plan to evenly spread your resources over the lifetime of the project, or do you plan some peaks in your communication? The communication plan also allows you to evaluate how successful the activities have been at particular moments in the research project.

The factors listed below need to be considered for a successful communication strategy[53] and part of the template 'communication and engagement plan' in Module 4:

- **Identify your target audiences**: When identifying your target audiences, you can categorize them into primary, secondary and intermediary target audiences. The primary target audience will be the group of citizens who feel highly engaged with your research project, and who are the most affected by the research aim. This group will contribute the most when it comes to collecting or analysing data. A secondary target audience is a group who is aware of, but not directly involved in, the project. A secondary target audience might become a primary target audience, for instance a government authority that becomes interested in your research. Lastly, an intermediary target audience is a network, an organisation or a person that might connect you to others, a teacher forum if you like to engage youngsters for instance.
- **Get to know your target audiences:** The better you understand your target audiences, the more effective and personal you can make your communication. In listing your target audiences, it is also good to have specific details about them. What is the size of the group? What is the average age? What is the gender distribution? And what is their level of education regarding the research topic? What are their motivations to join your research project? Not understanding your target audiences, and not knowing what stimulates them to be part of citizen science, is one of the biggest pitfalls. In the planning and design phase of your research, you can look into already established research studies to see if you can find any interesting information related to your target audience. You can also decide to develop a short intake survey once citizens subscribe to your research. In this way, you can log their former experiences, knowledge and motivations, and employ the right strategies and tools to recruit them.
- **Use a diverse mix of communication channels and tools**: You can use a wide variety of channels and tools for supporting your communication activities, either digitally, on paper or face-to-face. When identifying and describing your target audience, you can also match it with the most efficient communication channels and tools. Choosing the right medium ensures that your message arrives to your intended audience, and increases the chances that your audience reads, hears, or sees your messages. Depending on the purpose of your message, you might choose a different medium of communication. For instance, if you

want to inform and train citizens, you might choose physical workshops so you can provide the opportunity for asking questions. On the other hand, if you would like to inform about an urgent issue related to data collection, you might choose social media or personal e-mails. Try to be creative in the mix of media that you choose for your communication activities. Presentations with lengthy explanations should be balanced with playful, social events. Furthermore, using a varied mix of media will also affect the diversity of your project participants. Launching an open call via social or mass media will allow you to reach a huge number of potential scientists. If you combine this approach with more targeted communication, such as collaborating with intermediary organisations, then you will be able to reach out to more specific profiles.

- **Use of language**[54]: The language, specifically the tone of voice and its terminology, matter greatly when communicating with your target audiences. Getting the 'wrong' language might exclude citizens from the communication processes. Therefore, it is crucial that you reflect on how inclusive the language used is. For instance, is the language adapted to audiences of different cultural and literal backgrounds? Are gender differences taken into account? And are you using understandable language? Which terminology are you using for describing participating citizens (cf. Module 1)? Talking with participating citizens can help you to understand how they feel affected by it, and might enable you to co-create a more inclusive and understandable language.
- **Open communication**[55]: Citizen science is a two-way communication process between researchers, citizens and other stakeholders (e.g. policymakers, interest groups, etc.) involved in the research project. When planning your research project, you have to reflect on how you can stay in touch with participating citizens, but also how they can connect with you and other members of the community. You can question the preference of communication channels and evaluate what type of information they like to receive. During the executing phase, it is of critical importance that (personal) feedback is provided as it gives recognition for the citizens' contributions. If feedback cannot be provided immediately, then you can send a message that the collected data was successfully received and that the data will be validated within a certain period of time. Drop-out can occur at this stage due to a lack of openness about the results. After completing the task, participating citizens are eager to know more about the results. Therefore, it is recommended that once a task is completed you are open about the further steps in the research project, and you already provide some first insights through simple visualizations or statistics (e.g. the number of contributions, explanations about the analysis methods, insights into citizens' profiles, etc.). During the final stage of the research project, the final results are shared with the target audiences. Again, it is recommended that a two-way dialogue is stimulated and that the research results are not just presented during an event or published online through a downloadable report. Interactive workshops can ensure the sustainability of the results and can provide space for mutual learning related to (policy) recommendations or future research trajectories.

In Module 4, a template is provided to draft your own communication and engagement plan based on these crucial factors.

A practical guide to communication and engagement in citizen science:

It takes practice to stay open, accessible and inviting through communication. This practical guidebook equips you with a few tricks of the trade. The **first part** of the book focuses on the building blocks of a good communication plan. A communication plan reflects upon the project objective(s), the level of engagement, the target audience and its motivations and, finally, the evaluation of success.

The **second part** of the book focuses on tactics and tools that you can use for the engagement strategy. An engagement strategy helps you to reflect upon the expectations, motivations and behavioural aspects of your target audience to keep them on board in the long term. Six tactics and tools are provided, such as storytelling, gamification, and usage of social media, to support either initial or continued participation.

The **third and fourth part** of the book provide practical tips and tricks, as well as a template to start drafting your own communication and engagement plan.

The guide was published in 2019 by Scivil, the Knowledge Center on Citizen Science in Flanders, and in collaboration with SMIT, EOS Wetenschap and Tales and Talks. The content of the guide is based on studies of citizen participation and the real-life experience of science communicators. This guide is for anyone who finds themselves communicating and engaging with citizen scientists.

You can download the guide here in English and in Dutch.

Summary

Communication is a vital aspect of citizen science. A two-way dialogue is set up between researchers and target audiences, whereby values such as interaction, providing feedback, sharing knowledge and mutual learning are brought to the forefront. Good communication takes practice. Make sure there is a dedicated budget and team for managing these activities. Get started with your communication plan and check the Module 4 template 'communication and engagement plan'.

Further reading:

- The Scottish National Standards for Community Engagement might provide a useful reference point for ensuring high-quality and effective engagement processes. There are ten standards in total for setting up successful engagement with stakeholders, focusing on support, planning, methods, working together, improvement, etc. Indicators are provided for each standard, which can be incorporated into your communication and engagement plan.
- If you are interested in learning more about inclusive language, you can check out the book 'Inclusive communication' by Hannan Challouki. Furthermore, the organisation 'Wablieft', centre for clear language, helps you with writing accessible texts (for vulnerable groups). They organise workshops and also offer paid proofreading and editing services.
- This article by de Vries et al. (2019) performed a literature review on citizen scientists' preferences for communication of scientific outputs.

Share your thoughts and opinions – Time for reflection:

- Would you consider using mass media to promote your research (project)? Do you have any doubts or concerns?
- Do you have the necessary capacities in your team to support communication activities? How are roles divided?
- What are your experiences and tips for using social media for communicating about your research (project)?

2

Motivational strategies for participation

In addition to a communication plan, it is also effective to have an engagement plan in place[56]. Engagement stands for the active involvement of citizens in your research activities and will be defined by the chosen level of participation (cf. Module 2). Therefore, an engagement strategy will focus on the identification and monitoring of motivations which support or prevent citizen scientists from taking part in your research project. In line with citizens' expectations, the engagement strategy will also propose (new) tactics and tools to secure continued participation in the long term. During the implementation phase, the communication and engagement plans will be closely interconnected with each other. For instance, if monitoring tools reveal that participation rates are dropping, then new communication activities can be planned that stress particular motivations to take part in the project.

Motivations to take part in citizen science research can be very diverse, but are mostly intrinsically driven[57]. When citizens are intrinsically motivated, they engage in the research project because it is personally rewarding, or they find enjoyment in the process itself. If they were participating out of a reward or social status gain, then citizens would be more driven by external drivers which are not always directly related to the project. In most cases, citizens are motivated to take part because they like to contribute to science, or because they have an interest in the particular research topic. In citizen health science, the motivation is strongly linked to a personal interest in contributing towards a treatment or cure[58].

Case study: Reasons for monitoring air quality

As part of the development process for its engagement strategy, the hackAIR project surveyed 370 potential citizen scientists. An online questionnaire gauged motivations for, and barriers to, air quality monitoring and measurement in the neighbourhood. The leading motivations were: general curiosity about the measurement results (56%), concern about the local air quality caused by the perception of living in an area with poor air quality (43%) and personal health problems (30%). These reasons were used as triggers during opportunities to communicate later in the project.

Website: https://www.hackair.eu/

Motivations can also change over time. At the beginning of the project, citizens are mostly driven by the desire to learn, general curiosity and out of interest. Over time, these motivations rather shift towards scientific learning, social connections, and feeling appreciated[59]. Be aware that not everyone will stay till the end of the project. The drop-out rate is usually the highest at the time of initial participation, or just after it. This is mostly due to the usage of jargon, or a non-user-friendly application or data protocol. The drop-out after a longer term of participation will be mostly due to a lack of openness about the scientific process, lack of feedback about the results, and a lack of recognition and appreciation.

Case study: Engagement metrics of the Eye for Diabetes project

'The Eye for Diabetes' project motivated citizens through Zooniverse to train an algorithm for identifying symptoms of diabetic retinopathy. Citizens were invited to annotate retinal images for symptoms of the disease. During the lifetime of the project (January 2019–June 2020), a total of 3,950 citizens registered to take part in the project. Halfway through the project, the number of contributions increased due to making the platform more accessible to international users by adding an English version. Peaks in contributions could also be correlated with organised events, and the start of the COVID-19 pandemic. The statistics suggest that half of the classifications were performed by non-registered users. On average, one citizen scientist watched and labelled 24 retina images, while the top contributor labelled 1,000 images. This shows that only a small percentage of the participating citizens were hardworking and loyal to the project, while the majority of contributions were made by a larger group of citizens who passed by unplanned.

Website: https://www.oogvoordiabetes.be/

Summary

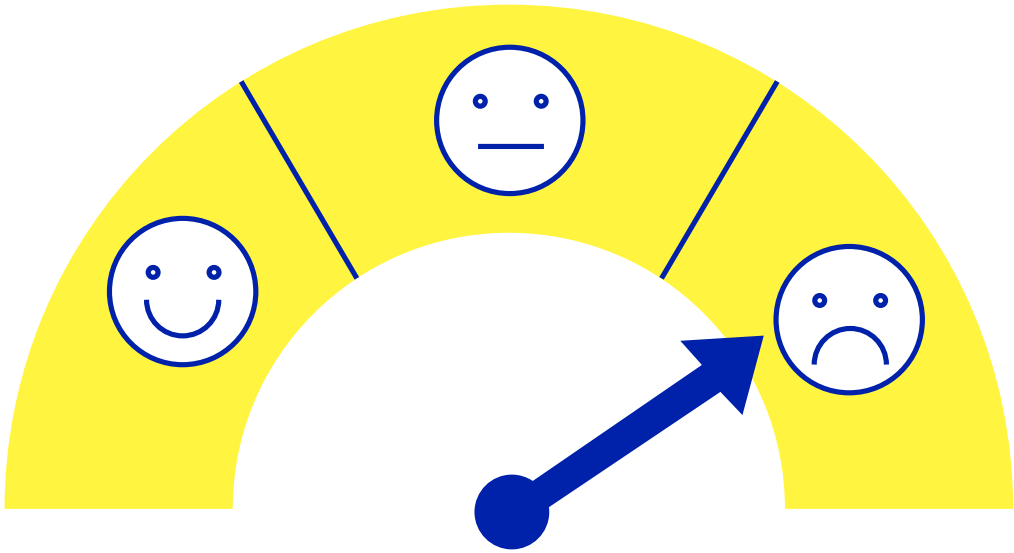
It is recommended that the participation rates and the motivations of citizen scientists are monitored over time. Motivations can be very diverse, and what works for one group of citizens might be less effective for other groups. Based on gathered insights, you will have to adapt your engagement and communication plan, and perhaps also other elements of your project design if the drop-out is caused by accessibility issues.

Further reading:

- Did you already hear about the 90-9-1 principle in internet culture[60]? This rule states that in online websites, 90% of the participants only consume content, 9% change or update content, and 1% adds content.
- The motivations of citizen scientists are usually investigated through social science research, by organizing surveys or in-depth interviews. If you would like to collect information about the motivations of the citizen scientists in your research (project), you can use the following questionnaire by Levontin. The questionnaire consists of 18 categories, with 58 items in total. Depending on the scope of your research (project), you can select the most appropriate items.
- For monitoring the participation rates in your online research (project), you can rely on several engagement metrics. Aristeidou et al. (2017) propose looking into the activity ratio (the number of days a participating citizen was active and contributed versus the days she/he/they remained in the project), the activity duration (the number of days a participating citizen is linked to the project versus the total number of days) and the lurking ratio (the number of days a participating citizen was browsing content on the citizen science platform, but not contributing). Based on these metrics, you can categorize your participating citizens into different engagement profiles (e.g. hard-working volunteers, loyal volunteers, lurkers, etc.).
- This toolkit of citizenscience.gov provides further information about how you can build a community. Tips are provided for knowing, engaging and nurturing the community.
- The BiodivERsA project provides an interesting handbook on stakeholder engagement in research projects. It includes practical guidance for better planning and engaging with non-academic stakeholders, including policymakers.

Share your thoughts and opinions – Time for reflection:

- Do you have any tips on how you can manage the expectations of participating citizens in your project? Citizens may expect to see rapid change, while in reality this might not be the outcome of the research (project).
- What are potential drivers and barriers for participating in your research (project)? Are there clearly stated benefits for participating citizens?
- How can you ensure continued participation in your research (project)? Which tactics and tools could help?



3

Mechanisms for ensuring data quality

Regarding the quality of the citizen science data, there are certain questions and doubts that can arise. Are citizen scientists able to gather reliable data? Can they intentionally or unintentionally influence the results? And are you measuring what you intended to measure in a correct way?

Different stakeholders might have different expectations about the data. As a researcher, you are looking for scientific accuracy in the data for achieving your analytical objectives. If policymakers are involved in the research project, they might have other expectations and needs regarding the data. For them, the data traceability might be most important, as they do not want to run the risk of inconsistency in information acquisition and processing. For the participating citizens, in turn, it should also be ensured that the data protocol is easy enough to follow so that they are not deterred from the project. A more rigid protocol can result in higher quality data, while a more flexible protocol can give more freedom to participating citizens – but with a higher risk of low data quality (cf. Figure 2). An agreement should thus be sought among all stakeholders involved on the definition of (acceptable) data quality.

Illustration based on the balance between autonomous citizen science and rigid protocols[61].

Strictly speaking, data quality is referring to the correctness, accuracy and completeness of the data[62]. However, it is recommended that a more holistic approach is taken, and that aspects of data contextualisation (communicating about the context in which data and information were created), data reuse (clarifying data ownership and using open standards) and data interoperability (ensuring unproblematic reuse)[63] are also looked into. These three factors all have an influence on the data accuracy of your project.

Overall, it must be stressed that issues related to data quality are not unique to citizen science. In more conventional science methods, the replicability and reliability of the research results can also be a hurdle. Furthermore, studies also show that the quality of the data in citizen science research is more likely to be determined by the study design, the methodological approach and communication skills, rather than the citizen engagement approach per se[64].

In order to ensure the data quality in your research (project), there are several mechanisms that you can set up during or after the generation of data[6566]:

- **Pre-test your data protocol:** Before launching your citizen science campaign, it is advised that you thoroughly test your protocol. As such, you can identify errors in measurements and ameliorate the design. It also helps you to spot the types of errors participating citizens can make, and maybe even to investigate ways you can rate or reward a good quality contribution of a citizen. It is best to display examples or errors anonymously without embarrassing anyone.
- **Training of participating citizens**: First of all, training can help to teach citizens how to collect, process or analyse the data. Clear step-by-step descriptions will help them to improve their scientific literacy and to perform the task in a good way. Training can be organised face-to-face or through online tools and platforms, e.g. manuals, FAQ, tutorial videos, etc.
- **Data validation**: Data validation mechanisms ensure that the data meet certain criteria and can therefore be used or analysed. For instance, validation checks in surveys that ensure that you write the data or a postcode in the correct format.
- **Data verification**: Next, the data submitted by citizen scientists can be checked and verified in collaboration with more experienced citizens, or by researchers. This can be done for the whole dataset, or only for randomly chosen samples of the dataset. On the Doedat platform (DoIt) of the Meise Botanical gardens, the scientists are verifying the data themselves. They still consider this way of working to be more efficient than when they have to make the observations without the help of citizens. Nowadays, you can also use software-based systems (based on artificial intelligence) that automatically identify outliers.

- **The law of large numbers:** Ensuring a large number of samples or observations, or involving citizens in a measurement on multiple occasions can ensure better data quality. You collect a larger amount of data on which you can make statistical corrections. With a large amount of data, you can also have duplicates, which can help you check the accuracy of the results. For instance, the Curious Noses project involved a large number of citizens in the measurement of NO_2. All participating citizens received two measuring tubes, which were installed at the same time. If the two measurements did not match, then the complete sample was excluded from the database and regarded as not reliable.
- **Systematically divide an area into segments or keep track of the sample frequency**: If applicable, it is also recommended that the periods and locations of observations are selected carefully. In order to make valid statements, it is best to systematically cover different types of areas in all seasons. For instance, Spinicornis maps the distribution of woodlice by dividing the Belgian territory into segments. They organise multiple field trips to each of those segments in order to systematically cover all seasons.

Summary

Although there is a certain distrust and scepticism towards citizen-generated data, citizen science can provide high-quality data – similar to more conventional methods. If the research (project) has a well-designed protocol and quality assurance in place, then the data can be used for both scientific and policy objectives.

Further reading:

- The data charter for citizen science (available in Dutch and English) can help you with further questions on data quality. This data charter is published by Scivil, the Flemish Knowledge Centre on Citizen Science, in collaboration with Digitaal Vlaanderen.
- You can read more about the usage of citizen science data for environmental monitoring in policymaking in this best practices report of the European Commission. It lists opportunities, challenges and potential benefits for policy uptake.
- This article by Fritz et al. (2019) presents a roadmap about how citizen science data can be used as an alternative source for measuring the United Nations Sustainable Development Goals.
- This study by Lovell et al. (2009) illustrates the effectiveness of participating citizens for sampling terrestrial savanna invertebrates in comparison to professional researchers. The results of the study show that there was little difference between the two samples, and that appropriate training helped to improve the validity of the data.
- In this article by Freitag et al. (2016), additional mechanisms and strategies are described for ensuring good data quality.

Share your thoughts and opinions – Time for reflection:

- Which data quality issues would you anticipate for your project?
- To what extent are you having concerns or distrust towards the usage of citizen-generated data in your research?
- How would you deal with participating citizens that have a particular agenda and who might cause significant bias in the data?
- Would you prefer to set up a peer review (i.e. by expert citizens) or an expert review of the data? What are potential challenges and benefits?

4

Citizen science tools and platforms for data management

Nowadays, digital tools and platforms offer great support for the collection, analysis and visualization of citizen science data. When you start to plan your research project, you need to reflect on whether you need any technological support and, if so, which type of platform or tool is best suited. The technological requirements will be greatly determined by your budget, your data protocol (cf. Module 2) and the project goals. In determining these requirements, you also have to account for the sustainability aspects of your data: in which format will you publish the data, and for how long can the information remain available? Make sure that you also know how to deal with certain technological challenges[67], e.g. are citizens able to collect data in areas that are out of connection, is the platform easy to use, and how & by whom will it be maintained in the long run?

The success of your research project will be determined by all these technical choices. It has been proven that data management via digital citizen science platforms can ease the interaction and communication between researchers and citizens, and can be cost-effective and time-efficient[68]. It can also be a motivational trigger for citizens to use and discover new technologies. However, digital technology is not always necessarily the best option. Sometimes, using pen and paper might be the best solution, when automated observations pose privacy concerns for example.

Case study: Muide Meulestede Morgen (Muide Meulestede Tomorrow in Ghent, Belgium)

Measuring instruments do not have to be high-tech. You can just as easily collect traffic data using only pen and paper. This method of pegging was applied in the 'Muide Muilestede Morgen' project. This urban renewal project has an eye for sustainable mobility. A number of residents raised the issue of the excess amount of through traffic at the Muidepoort.

More information:
https://stad.gent/nl/muide-meulestede-morgen

Sensors in citizen science

You can use advanced, measurement technology such as **sensors.** There are hundreds of different types available, and it is often difficult to see the wood for the trees. There are sensors in all price ranges, from simple devices costing a few euros to professional set-ups costing thousands of euros. In order to solve your scientific problem, it is best to first ask yourself what a sensor must be able to measure – and with what degree of precision and accuracy. At the request of the 'Agentschap Binnenlands Bestuur' (Agency for Internal Affairs) of the Flemish government, a market analysis was performed by the consultancy company PwC on the available sensors that can be used for citizen science. Based on the research domain and the challenge, a list of sensors has been made available for consultation, together with a how-to guide. In line with open science principles, it is recommended to go with open hardware, low tech, or do-it-yourself solutions from this list.

Existing online platforms and applications

You can also decide to make use of **online platforms and applications**. Citizen science platforms are web-based infrastructures with one single entrance point[69]. These platforms offer an overview and search function of active citizen science projects, often in combination with guidance and support materials. They can be categorized into (non-) commercial platforms, and platforms for specific projects or specific topics, either nationally or globally bounded.

Citizen science platforms have the advantage that most of them already have an established community base, and that they are well managed by the initiators. Online platforms like Zooniverse or 'DoeDat' (DoIt), offer a wide range of activities that can be performed by the participating citizens, often along with some community features (e.g. comment section, personal track records, blogposts, etc.). You can upload your dataset or raw data on these platforms and ask citizens to analyse those data. This often involves annotating images, making classifications or transcribing texts. With online platforms like these, you make use of the software behind the platforms. You offer your information or data, and you remain the owner of the analysed data afterwards. The results of the analyses of the citizen scientists are delivered in an open format (e.g. CSV-sheet). Of course, you can also develop your own platform or tool for data collection, analysis or visualisation. This could be based on open-source code, such as OpenStreetMap, or on request by a private company. Make sure that you have sufficient budget available for supporting these activities, and that they are pretested for their user-friendliness.

The following existing citizen science platforms can be used for data collection, analysis or visualisation; they are all entry-level:

- The Zooniverse is an international platform for the annotation and transcription of datasets, and includes more than one million interested citizen scientists worldwide. If you would like to run your project on Zooniverse, you will have to apply to the platform. In the project builder section, you can upload your datasets and choose the tasks you want the volunteers to do.
- DoeDat (DoIt) is the online crowd sourcing platform of the Meise Botanical Gardens, on which citizens can digitise their herbaria. The purpose of this crowdsourcing platform is to help the Meise Botanical Gardens to digitize their collections and to give citizens the chance to play an active part in this process. You can also post your project on the 'DoeDat' platform if it fits within the themes of the platform. For instance, Luca Schools of Arts has a project 'Flemish and Dutch flower still lifes from the 16th and 17th century'. The participating citizens are invited to describe the images as accurately as possible.
- iNaturalist is an international application and online community through which citizens help to identify plants and animals. You download a mobile application, take a picture via the application, and you upload it to the community. The Dutch variant of this platform is https://waarnemingen.be/ by Natuurpunt, Natagora and Stichting Natuurinformatie. Here, you also download a mobile application to upload your observation. Automatic image recognition helps to identify the species or animal.
- MijnTuinlab (MyGardenLab) is a Flemish platform which collects citizen science projects that can be run in your own garden. It is an initiative of Natuurpunt, Kenniscentrum tuin+ (Erasmushogeschool) and KU Leuven. Examples of projects are FlowerPower, Spin-City, Weekly Bird Count, etc.
- 'Vele Handen' (Many Hands) engages citizen scientists in the transcription of historical, often handwritten, documents. 'VeleHanden' is a crowdsourcing platform of Picturae. Picturae is a Dutch enterprise active in digitizing and opening up heritage collections for museums, archives and libraries at home and abroad.
- The BiodivERsA citizen science toolkit lists more useful tools and applications for biodiversity researchers.

Lastly, the following platforms can be used for listing and promoting your research (project) to citizens:

- SciStarter is an international platform which disseminates your project to a community of citizen scientists. SciStarter allows citizen scientists to track and earn credit for their contributions to science projects. They also offer some training modules.

- The Dutch-speaking platform for citizen science is "Iedereen Wetenschapper" (Everyone's a Scientist). You can submit your project to the website www.iedereenwetenschapper.be. If your project satisfies the conditions, they will send out a standard questionnaire and the editor at Everyone's a Scientist will post your project to the platform. Your project is published on the platform for free, and will be mentioned in the monthly newsletter and on the Everyone's a Scientist social networking site. They also offer paid services for editing texts, helping with recruitment strategies, etc. The platform does not offer any collection or analysis options.
- Lastly, you can also promote your project on the Eu-Citizen.Science platform.

Tips for building your own application or platform:[70] If you want to build an application or platform yourself, you should not underestimate the costs. Several online tools allow you to make a rough calculation of development costs for mobile apps: App Development Cost, Buildfire, Digitalya. You can build a citizen science application using these online tools; some of them are free while others are paid:

- Natural Apptitude (for ecology and conservation)
- Open Data Kit
- Siftr
- Spotteron
- ArcGIS Developers
- https://five.epicollect.net/
- https://www.citsci.org/ (for data collection and visualisation)
- The citizen science project builder of the Citizen Science Centre Zurich
- https://www.ushahidi.com/ (for crowdsourcing)

Summary

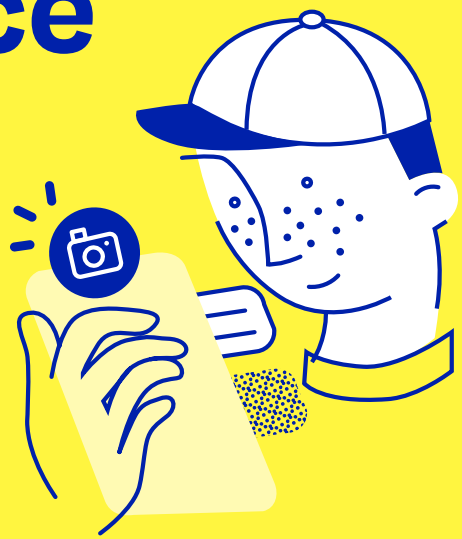
Defining the technological requirements for your research (project) can be a challenging task. If possible, we recommend leveraging upon existing open-source platforms and tools. Nowadays, many solutions are already available which offer data collection and analysis options, often with an already established community of citizen scientists. If existing solutions do not suffice, you can develop your own measurement devices, or rely on private companies that can help with custom development.

Share your thoughts and opinions – Time for reflection:

- Do you have any tips about using (low-cost) sensors for environmental monitoring? How do you balance the trade-off between data accuracy and the cost of the sensor?
- What are your experiences related to citizen science platforms for networking purposes?
- Can you recommend any other platform or mobile application for citizen-generated data collection or analysis?

Module 4

Getting started with citizen science



This module provides you with the necessary materials to get started with citizen science. You will find a step-by-step plan with templates and checklists, and other relevant resources to set up the activities. The step-by-step plan guides you through six different phases, from the inception to finalization of your citizen science research project.

Depending on your role in the research project, you will follow this step-by-step plan in a different way. You can explore all phases in sequence or focus on one. The extent to which you follow this plan also depends on the project's objective. If your project focusses primarily on data collection, the focus will be on the first phases of the project. If there is more emphasis on raising awareness with action-oriented results, the focus will lie in the last phases of the project.

Goal: At the end of this module, you have hands-on knowledge on how to conduct a citizen science project, both for small and large-scale research projects.

Phase 0 – Consider • Identify a research question • Determine if citizen science is right for your research	**Phase 3 – Launch** • Promote and publicize your project • Communicate & retain motivation • Receive data, check the quality and provide feedback
Phase 1 – Prepare • Define the project objectives • Assemble the project team • Map your stakeholders • Find resources and funds • Consider privacy and ethics	**Phase 4 – Analyse** • Analyse and report the data • Share and publish your data • Evaluate your research (project)
Phase 2 – Develop • Choose citizen science tools • Successful data management • Develop a communication and engagement plan • Inclusive citizen science	**Phase 5 – Sustain** • Citizen science in the long run • Valorising research for society

From start to finish: citizen science checklist

Phase 0

Consider

Before you start, you should reflect upon your research question and consider whether citizen science fits the issue at hand.

Identify a research question

The first step is to identify a research question. In *applied research*, citizen science can solve specific community or policy-driven questions and improve understanding on a particular issue. It can also support transdisciplinary research and provide value to all involved stakeholders, from which clear, practical solutions can be derived. In *fundamental research*, citizen science can help in theory building and expand the knowledge base (e.g. new measurement instruments, data models or frameworks). It will result in findings of significance and value to society in general. However, it may not directly result in a solution to a practical problem.

Case study – CO-NATURE

CO-NATURE is an applied-driven research project that explored the potential of incorporating ecosystem services and nature-based solutions into development plans for Brussels. Through citizen science, it explored which nature-based solutions could be implemented, and where these would be most beneficial. Furthermore, the project helped to build understanding on how citizens in Brussels use and value green spaces. The outcomes of the research were used for co-creating scenarios with experts and citizens, which ultimately informed urban greening policies.

This four-year research project (December 2018 – November 2022) was a collaboration between the ULB and VUB, and collaborated with Brussels Environment and BouwmeesterMaitreArchitecte. Innoviris provided financial support for the project.

Website: https://www.co-nature.org/

A research question can be formulated top-down by the research institution, but it can also be formulated by a community organisation, or an individual citizen. These latter bottom-up questions often arise out of a concern within society. In the database of the Science Shop ('Wetenschapswinkel') you can explore different research themes and questions, submitted by non-profit organisations in Belgium. Based on these inputs, you can jointly determine the scope of the research.

You can also opt to identify the research question in a participatory way. Participatory methods such as online voting, collaborative workshops or crowdsourcing might be helpful to identify or prioritize your research question.

Let's get to work!

Tool 1– Identify your research question: guiding questions

Use the following template, developed by the Citizen Science Contact Point of the VUB, to identify your research question and the underlying problem. To help you formulate a strong research question, some helpful tips are provided in the document.

Please contact citizenscience@vub.be if you have any further questions, or if you need personalized support for this activity.

Tool 2– CitieS Health toolkit

You can identify your research question in a participatory way. The CitieS Health toolkit provides helpful tools for identifying citizens' concerns and for turning them into a research question.

Tool 3– Problem definition

Identifying an innovative research question can be time consuming. This template, developed by NESTA, helps you to define a problem statement by exploring its underlying factors.

This template is particularly helpful for applied research projects.

Determine if citizen science is right for your research

Once the research question is identified, you need to make sure that a citizen science approach fits. Citizen science does not fit for all research topics. In certain circumstances, more conventional science methods or other types of public engagement mechanisms might just do the trick or might be even better suited.

Before you begin, we recommend filling in our self-reflection test and assessing the suitability of a citizen science approach through our fill-in template. This template is based on Module 2 of this training programme.

Test: Are you ready for citizen science?

This test, developed by the Citizen Science Contact Point of the VUB, helps you to self-reflect about certain attitudes and working practices when performing citizen science research.

Fill in this fun test and get to discover your readiness level!

Tool 4 – Determine if citizen science fits your research

This assessment and support document helps you to self-reflect on whether citizen science is right for your research. You can assess the suitability of a citizen science approach through several questions.

The document can be used by the project coordinator or by individual team members. Please contact citizenscience@vub.be if you have any further questions, or if you need personalized support for this activity.

Tool 5 – A decision-making framework for citizen science

In the handbook 'Choosing and Using Citizen Science' from Pocock and colleagues (2014) you can find a decision-making framework for environmental monitoring (p.14-19). You can assess whether citizen science is suitable for you, and which type of citizen science you should consider.

Phase 1

Prepare

By now you have thoroughly considered whether a citizen science approach fits your research project, and what your research question is. You already have a high-level idea of how you envision your research project, and now it is the time to concretize it further.

In this phase, you will sharply define the project objectives, assemble the project team, map your stakeholders, find the necessary (additional) resources, and reflect on privacy and ethics.

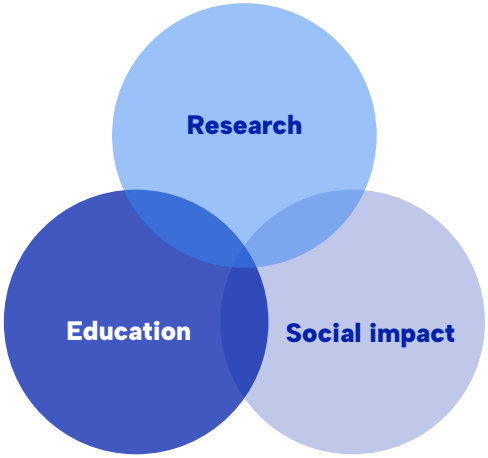
Define the project objectives

The most common objective of citizen science is to answer a specific research question. Acquiring new data and insights for research purposes is, therefore, always at the heart of citizen science.

At the same time, other objectives such as generating social impact or education are also worth considering:

Objectives of a citizen science project

- Contribute to research: collecting data
- Educate and raise awareness: increasing knowledge about a particular theme or issue, increasing understanding and support
- Create social impact: strong locally embedded projects in which people seek a solution to social issues



You can combine several objectives or have one primary objective. Your primary objective might focus on data collection for research purposes and less or not at all on social impact. Of course, you can combine both objectives, this being the most ideal scenario. Try to be realistic in clarifying your project aims. Going for all three objectives may be highly commendable, but in reality it might be difficult to achieve. Being too particular about a strict method of data collection for achieving your research objectives might cause citizens to drop out after a while.

It is important that you clearly communicate the project objectives to the participants: is it an experiment, a short-term intervention, or inspiration for another project in the long run?

Tool 6 – Reflect on your project objectives

Use this template, developed by the Citizen Contact Point of the VUB, to reflect on your project objectives: where in the Venn diagram would you place your research project?

Please contact citizenscience@vub.be if you have any further questions, or if you need personalized support for this activity.

Tool 7 – Impact statement

An impact statement summarizes how your project might make a difference in the lives of people, communities and the environment. The impacts of citizen science can be diverse, from scientific to societal, economic and ecological outcomes.

Use this template to write out your impact statement. Don't be shy to print it out and share it with not only your project colleagues, but also with your stakeholders!

Please contact citizenscience@vub.be if you have any further questions, or if you need personalized support for this activity.

Assemble the project team

Citizen science is about working together. In this step, you determine who is going to do what exactly. Will you take on the coordinator role as a researcher yourself? Who are you going to outsource to? Which parties will you bring together?

To accomplish the tasks discerned in your research project, one or several people are necessary (depending on the size of your project).

Tool 8 – Assemble the project team

Use this project team sheet, based on the work by Muki Haklay[71], to assemble the project team for your citizen science project.

Fill out who you have in mind for each role.

Map your stakeholders

For your citizen science project to run smoothly, it is important to consider in advance the relevant stakeholders that will be involved. A stakeholder mapping exercise allows you to identify these stakeholders and, subsequently, consider how to engage with them and which ones to focus on.

Your most important stakeholders will (almost) always be your participants, that is the citizen scientists. The level of participation you require from them might differ, depending on your project objectives and resources. It might be interesting to consider which of the following participation levels you expect from your stakeholders:

Level 4 'Extreme'	Collaborative science – problem definition, data collection and analysis
Level 3 'Participatory science'	Participation in problem definition
Level 2 'Distributed intelligence'	Citizens as basic interpreters
Level 1 'Crowdsourcing'	Citizens as sensors

Tool 9 – Map your stakeholders

To conduct your stakeholder analysis, Tool 9, *Map your stakeholders*, offers a useful three-step guide.

Find resources and funds

As for every research project, finding the necessary funds and financing can be a daunting but necessary task.

Scivil keeps an updated page on possible financing opportunities for citizen science here: https://www.scivil.be/en/oproepen. While there are (occasional) calls specifically for citizen science projects, you can also weave a citizen science approach into "classic" research funding calls.

The following suggestions from Scivil are interesting to take into account when applying for regular funding calls for citizen science. Two important take-outs are to:

- **Stress why the project needs citizen science**: what is the added value of a citizen science approach for your project? How and why is it more suited than a traditional research approach?
- **Emphasize the societal and educational objectives/impact**: the societal and educational benefits and objectives of your citizen science project (cfr. Define the project objectives) can create significant added value to your project when compared to traditional research. Do not hesitate to stress this!

Consider privacy and ethics

Just like any regular research project, a citizen science project should be conducted ethically and without causing harm. It is therefore important to carefully assess the potential consequences the activities may have on your participants, the study objects, and the surrounding environment.

The following resources might help you to learn more about privacy and ethics:

- A toolkit for data ethics in participatory science from the Citizen Science Association
- A training from SciStarter about data ethics "Think like an ethicist"
- A training module on ethics from University College London (module 7: 'Legal and ethical issues')
- Participatory Approaches to a new ethical and legal framework for ICT: PANELFIT
- A handbook on managing intellectual property rights in citizen science from Commons Lab Wilson Center

Ethics Committee and Data Protection Office @VUB

VUB has several Ethics Committees, as well as a Data Protection Office. The Committee provides ethical advice to researchers. It verifies the compatibility of research submitted for its opinion with ethical principles and standards. It can provide general ethical policy advice concerning research developments. You can find more information on the VUB website.

The VUB also organizes a yearly 'Ethics Week' for researchers from within and outside the VUB to reflect on how ethics contribute to excellent research. There is also a dedicated course on Good Academic Research Practices (called "Mind the GAP"), jointly developed by five universities in Flanders.

EUTOPIA members working at VUB can reach the Legal & Ethics Office at LEO@vub.be. They provide advice regarding and templates for informed consent forms and privacy policy information sheets.

Tool 10 – Ethical considerations checklist

Whereas an ethical committee (ethics board) assessment provides a more elaborate and even necessary ethical assessment, Tool 10 allows you to make your own initial ethical reflections regarding your project and to draft an information document about the ethical standards in your project, to be shared with participants.

Tool 11 – Citizen science data charter

The citizen science data charter and guide of Scivil contains recommendations and tips for handling data in citizen science projects. Chapter 2 deals with 'privacy and ethics'. The guide is available in Dutch and English.

If you have any specific questions about this, you can contact info@scivil.be.

Phase 2

Develop

In this phase, you make all the necessary preparations before the research project kicks off.

You choose the citizen science tools for data collection, analysis, and visualisation; or perhaps you decide to develop your own sensor or mobile application. During the project, citizen scientists should know how to collect data. Therefore, a data protocol should be outlined. Additionally, everything related to successful data management should be written down in a plan. Lastly, to prepare the launch of your project, a communication and engagement plan can offer guidance.

Tools for citizen science

There exist different tools available for conducting citizen science. Overall, there are tools to manage the data collection, storage, analysis, and visualization. Most of these tools are freely available and published through an open license. For other tools, such as sensors and customized apps, a specific starter sum must be paid.

However, not all citizen science projects need to rely on digital infrastructure. A simple starter kit with pen and paper might also do the trick.

To keep up to date with the most recent tools for conducting citizen science, we recommend consulting the repository of eu-citizen.science.

Tool 12 – Tools for citizen science

This inventory, developed by the Citizen Contact Point of the VUB, lists the main currently available citizen science platforms, mobile applications, sensors, and open data repositories.

Citizen science platforms[72] offer a wide range of features, from data collection to analysis and visualization of the data. Some of these platforms already have a pool of registered citizen scientists, with built-in community features for communication and engagement. Either in stand-alone or in conjunction with web interfaces, there are dedicated mobile applications available to organize measurement campaigns.

In the inventory you can find tools applicable to the European context, and freely available unless mentioned otherwise. Platforms, applications, or sensors that are project or organisation specific, and thus not reusable, were not included in this list.

Please contact citizenscience@vub.be if you have any further questions.

Successful data management

The Citizen Science Data Charter

Data management is a fundamental aspect of the success and impact of a citizen science project. It is recommended that these issues are reflected on at the beginning of the project to maximise data re-usage. The Citizen Science Data charter from Scivil is a helpful instrument for reflecting upon the data quality, ownership, data hygiene, interoperability, etc. This charter consists of 26 principles for successful data management. These principles are non-binding, but highly recommended.

Summary of the contents of the data charter for citizen science:

Open attitude	Citizen science is open science. Making your project outcomes available to the outside world in a(n) (ethically and legally) correct way is encouraged. For instance, you can publish your data and software under an open license, publish your results in Gold Open Access Journals, etc.
Privacy and ethics	Since you will be working with people in citizen science, it is best to consider the basic rules of privacy and ethics from the start. In addition, some guidelines are provided to communicate clearly about intellectual property and copyrights.
Data hygiene	These guidelines help you to properly structure and document your data so that others can understand it more easily or can link it to other data afterwards.
Data standards and formats	By using the right names or codes for everything you measure, and by providing the data files in a file format that everyone can 'read', you ensure that data from different projects can be linked together in the future, if necessary.
Metadata	Data are described by 'metadata': that is, data about the data. By using metadata, you ensure that your citizen science project is findable for everyone.

Tool 13 – The Citizen Science Data Charter

Use this fill-in template to reflect about good practices of data management for your citizen science project. The template is developed by Scivil, the Flemish Knowledge Center for Citizen Science, and set up as a supplement to the 'Guide to Data Charter for Citizen Science[73]'.

Please contact info@scivil.be if you have any further questions, or if you need personalized support for this activity.

The data collection protocol

Sometimes, suspicions arise regarding citizen-generated data. The collection, analysis and interpretation of data can sometimes go wrong. With appropriate planning and measures, you can solve many uncertainties and avoid pitfalls.

Via a well-defined data collection protocol, you can take appropriate measures to avoid errors in the data collected. A data collection protocol defines a set of rules for the citizen scientists on how to collect data. How much time does it take for a participant to collect data? What is the frequency of data collection? Which method is used? How is the data reported?

Citizen scientists should know when, where and how to collect data. It is recommended that each step is thoroughly described with precise instructions, since this will motivate them and reduce the number of errors.

To carry out the data collection correctly, there are several possibilities to support your citizen scientist with the necessary supporting materials:

- Video clips
- Step-by-step instruction manuals
- A list of frequently asked questions
- Training workshops
- Organizing a webinar with the opportunity to ask an expert questions. This can also motivate participants who want to gain more in-depth knowledge on the topic.
- "Train the trainer" modules: you provide training to a number of participants in your project, who in turn will help other participants. This is a (cost-)efficient way to support a large group of participants.

Tool 14 – The data protocol

Use this template[74], developed by the Citizen Contact Point of the VUB, to formulate a set of rules for your data protocol. You can also consult the Citizen Science Data Charter in the next step for more useful tips about data management.

Please contact citizenscience@vub.be if you have any further questions, or if you need personalized support for this activity.

Develop a communication and engagement plan

Citizen science is a two-way communication process between participating citizens and researchers, or other stakeholders. When planning your project, reflecting on how you can stay in touch with participating citizens, but also on how they can connect with you and other members of the community, is crucial for both initial and long-term engagement.

With the help of a communication and engagement plan, you describe all the communication activities by which you plan to engage your target audiences. You list the steps in chronological order, and you link them with the relevant target audiences, the tools and channels, and the aims you hope to achieve. The goal of your communication and engagement plan is to foster the participation of lay citizens in your activities. To be successful in this endeavour, it is helpful to understand that citizens' decisions to volunteer are influenced by three factors: the awareness of the opportunity's existence; the fit between the opportunity and the person; and the person's motivation (Hobbs & White, 2012).

Recruitment – awareness of opportunity

As such, the first step of your communication strategy should be to **make citizens aware of the opportunity** to participate in your activities, to "recruit" them. In this initial communication phase, you can opt for a generic approach, a specific approach, or a combination of both. When you take a generic approach, you publicise your project through an open call: you target a large number of potential citizen scientists, without any restrictions on the profiles or audiences. Social media, mass media, flyers, etc. are useful communication channels for a generic approach. Research shows, however, that a generic approach does not always deliver a diverse target audience in terms of gender, age, or educational level[75]. You will be able to reach out to a lot of people, but most likely you will end up with a biased citizen science profile: white, male, middle-aged and with prior knowledge[76].

With a specific approach, you target specific profiles of participants. Collaborations with existing networks and organisations work well for a specific approach as they allow you to make direct contact with your target audience. Sending personal invitations or contacting people on member lists are other options.

In a combined approach, you start your recruitment process by a generic approach through an open call. Depending on the specificities of your project, you set target numbers regarding certain profiles, and, depending on the citizen scientists recruited in the generic phase, you set up a specific approach to try and reach the missing profiles. This is particularly interesting for projects where the data collected need to be representative of e.g. geographical coverage, elements associated with socio-economic characteristics, etc.

Communication – understanding citizens' motivations

However, making citizens aware of the opportunity to participate is not sufficient if your message does not resonate with them. This is why **understanding their potential motivation to participate** is crucial.

The motivations of citizen scientists to take part in your project can be diverse. Generally speaking, we can distinguish between the initial motivation, i.e. motivation that has led the citizen scientists to first engage with the activities (e.g. curiosity concerning the technology involved), vs. continued motivation, i.e. motivation that keeps the citizen scientists engaged in the long term (e.g. working towards a scientific goal). Template 15 "Initial motivations" helps you to reflect on the initial motivation of your target group(s). More information about long-term engagement can be found in phase 3.

Tool 15 – Initial motivations

Use this template to consider in what ways your citizen science project might resonate with participants. It can provide great insight into their motivations and for what reasons they feel drawn to your project. This information is, in turn, useful to incorporate in your future communication and engagement with participants.

Please contact citizenscience@vub.be if you have any further questions, or if you need personalized support for this activity.

Tool 16 – Communication and engagement plan

This template is developed by the authors of the handbook 'A practical guide to communication and engagement in citizen science', published by Scivil. You can find more information about crucial design factors for developing a communication and engagement plan in Module 3 of this training programme.

Please contact info@scivil.be if you have any further questions, or if you need personalized support for this activity.

Inclusive citizen science

Participants in citizen science projects are not always representative of the general population. The typical citizen scientist is white, middle-aged, highly educated, male, and has a keen interest in science and research. It should not come as a surprise that this profile is strongly represented in citizen science projects; they are motivated and have the time, resources and expertise to participate in scientific research.

Involving disadvantaged groups from low socio-economic classes and ethnic-cultural minorities in policy and research is gaining interest in citizen science. While a bias in the profile of your participants might not pose a problem regarding the data collected in some instances, in some projects this will influence some aspects of the data, e.g. geographical coverage of disadvantaged neighbourhoods, interlinking with social aspects, etc. Additionally, ethical concerns associated with such a bias in the profile of your participants should be reflected upon.

If you want to work inclusively, you need to make explicit choices during your project design, i.e. target the fit between your target group and the opportunity of participation provided to them. In that case, the citizen science activities will need to have a purposeful design, which considers diversity and accounts for the needs and expectations of minority groups. You will need to think up front about how you intend to offer equal opportunities to participate in your project.

If you decide to attract people who are traditionally less well represented in citizen science, it is important that you also reach out to the right partners (cf. communication & engagement plan). Arrangements with local organisations and intermediaries can help eliminate some of the initial barriers to participation.

Tool 17 – Inclusiveness checklist

This template, developed by the Citizen Contact Point of the VUB, helps you to set up inclusive citizen science. The template is a checklist with good practices to reach underrepresented groups, or vulnerable and marginalized communities.

Please contact citizenscience@vub.be if you have any further questions, or if you need personalized support for this activity.

These further resources can help you to set up inclusive citizen science:

- A progressive's style guide by Hanna Thomas (SumOfUs.org) and Anna Hirsch (ActivistEditor.com)
- Organize events that centre on diversity, equity, and inclusion, including a conference design checklist (OpenCon, 207)
- Easy English versus Plain English (by Centre for Inclusive Design)
- ECSA guidelines and policies
- Guide to design and layout (by Plainenglish.co.uk)
- Helder en inclusief communiceren (Dutch only, by VVSG)
- Inclusive communication – policy brief (Council of Europe)

Phase 3

Launch

In this phase, you launch your citizen science research project. This is the phase where data are collected, and you generate and maintain engagement with participants.

Promote and publicize your project

In this step, you launch and promote the research project. The prepared communication and engagement plan, in which you identified the target groups and communication channels, will now be carried out. You make the necessary communication materials available, e.g., a project website or a social media page, with a clear notion of your data collection and analysis tools.

At this stage of the project, you will also share the supporting materials (instructional videos, how-to guides …) and you make sure that a community manager is available to answer questions.

To promote and launch your project and gain traction, you can exploit the power of the media to the fullest. You can organise a press briefing, send out a press release, invite (local) newspapers, TV stations or influencers, provide visual materials, organise a kick-off event, etc. A strong brand can also help you to build up recognition, for instance by having a clear brand image, a tagline and brand personalities who help you to promote your project.

By promoting your research project, you attract participants and try to build a community. To support this, you need regular communication and interactions. It might be worth asking for an external communication and marketing agency to support you with these matters, or to reach out to the central communication department in your research organisation.

Tool 18 – How the Department of Research – Outreach & Communication (ROC) can help you promote and publicize your project at VUB

ROC believes that you, as a researcher, have something to offer, no matter what stage of your research career you're in. And we're here to guide you along the way, to help you interact with society and have a direct impact on the world around you. You'll gain powerful skills, and your resume and funding applications will be better for it.

Ready to share your passion for your citizen science research project with possible participants and a broader audience? This list provides an overview of all the ways ROC can help you to promote and publicize your project.

Communicate & retain motivation

The motivations of citizen scientists to take part in your project can be diverse. As explained in phase 2, we can distinguish between the initial motivation, i.e. motivation that has led the citizen scientists to first engage with the activities (e.g. curiosity concerning the technology involved) versus continued motivation, i.e. motivation that keeps the citizen scientists engaged in the long term (e.g. working towards a scientific goal).

Depending on its nature and duration, your project might require ongoing engagement with its target audiences. Your communication and engagement plan (cf. Phase 2) should therefore provide this long-term commitment by planning for systematic follow-up, contact moments, and/or prompts for data entry.

Be aware that the number of citizen scientists who drop out is highest at the first contact with the project, or just after. The reasons they choose not to participate anymore are diverse, such as too much jargon used, a complex data protocol, but also a perceived lack of appreciation or openness about the results.

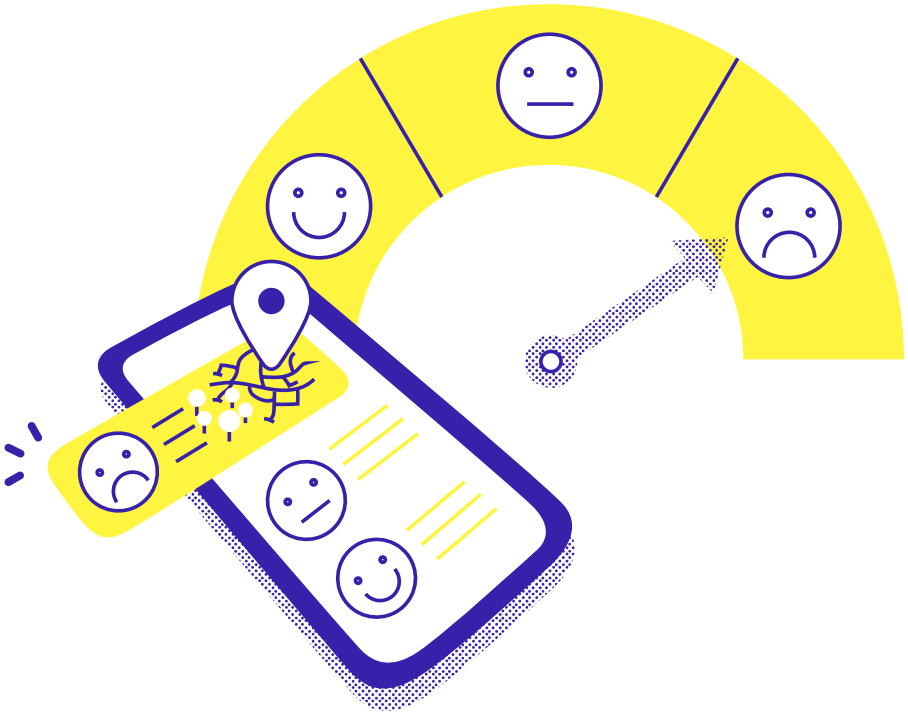
There is thus more needed than just an initial or regular contact with your citizen scientists to foster (long-term) commitment. It is a good idea to take a moment and reflect on your citizen scientists' motivations for participation in the long run. The motivations of citizen scientists are usually investigated through social science research, by organizing surveys or in-depth interviews[77]. Based on these insights, you can foster continued participation and ensure that they do not drop out.

Tool 19 – Long-term engagement

The drop-out rate in a citizen science project is highest at the time of initial participation or shortly afterwards. A lack of openness and understanding of the scientific process and the research outcomes are the most common reasons.

Use this template to reflect on how to foster continued engagement by your participants by considering long-term motivations and barriers to participation.

Please contact citizenscience@vub.be if you have any further questions, or if you need personalized support for this activity.



Receive data, check the quality and provide feedback

Once you launch your research project, participants will start with their contributions. This is the moment when data or metrics are collected and submitted. It is recommended that you monitor the chosen citizen science tools, and regularly check for technical problems in receiving the data. It is also important to check for data quality problems related to the data collection protocol[78], i.e. are participants following it correctly? Is it correctly implemented? Is it comprehensive? Based on your observations, it might be necessary to put additional data validation and verification mechanisms in place.

At this stage of the project, you will also make sure that you are able to provide quick feedback. This will help motivate participants by demonstrating that their efforts are taken into consideration and are helping the project move forward. You can distinguish between direct feedback, e.g. if you will be working with data submissions, you can send out an automated thank-you email, or a pop-up message indicating that their contribution has been taken into consideration. This serves as a validation to the citizen scientist in being certain that their activity (data collection or data analysis) has been registered and will be considered. A lack of a validation message can lead to confusion about the submission process or a feeling of failure.

For more extensive feedback, you can use a recurring newsletter or intermediate physical meetings and can communicate more generally about the progress of the project, e.g. number of contributions by citizens scientists in the last month, percentage of data analysed so far, etc., showcasing that their combined efforts are contributing to the project in a tangible way. When giving feedback, do not make too much use of personal communication, but bundle your messages and communicate through generic channels.

Tool 20 – Data quality template from the ACTION toolkit

It is useful to periodically evaluate your data quality. Use this Data Quality template by Baroni[79] from the ACTION toolkit to identify data quality dimensions, data quality indicators, and quality control activities.

Further resources on data quality of citizen science data:

- This article from Downs et al. (2021) describes several quality assessment and quality control issues in citizen science. They also offer recommendations on how to improve the citizen science data quality.
- This article from Wiggins et al. (2011) lists 18 mechanisms for data quality and validation in citizen science.

Phase 4

Analyse

In this phase of your citizen science research project, you analyse the data and report the results. This is the moment whereby you can start sharing your data on open repositories – if possible (e.g. no personal data). This is a key trademark of citizen science.

Finally, you can also evaluate the success factors and pitfalls that you experienced along the way: what went well, and what could be improved?

Analyse and report the data

After the data collection, you can start with the analysis and interpretation. The analysis can be done by the knowledge institution which has the necessary experience in scientific data analysis, but also by the citizen scientists. By involving citizens in this phase, you can increase co-ownership and ensure that the interpretation is not one-sided. This is of high relevance when you are tackling a societal issue that is close to the heart of citizens. Through dialogue between scientists and citizens, or other stakeholders, you can generate a broad support for the conclusions.

After the analysis, you communicate the research results. You share the results with your target groups and any involved stakeholder. It is best that the results are tailored to the target group. For instance, you can opt for a more accessible infographic for the general public, while an in-depth report can be sent to a more professional audience. You can also disseminate the results through a personal contact moment with your citizen scientists, contact the press, send out a newsletter, etc.

Tool 12 – Tools for citizen science (cf. Phase 2)

This inventory, developed by the Citizen Contact Point of the VUB, lists the main currently available citizen science platforms, mobile applications, sensors, and open data repositories. Some of these tools also offer built-in analysis and visualisation options. More specialised analysis and visualisation tools are also added in this list.

In the inventory you can find tools applicable to the European context, and freely available unless mentioned otherwise. Platforms, applications or sensors that are project or organisation specific, and thus not reusable, were not included in this list.

Please contact citizenscience@vub.be if you have any further questions.

Share and publish your data

Sharing your data usually takes place at the end of a research project. However, open science can be practiced throughout all stages of the research project and the decisions about data publishing should ideally be managed in a data management plan (DMP) at the start.

Within open science practices, the data and metadata are made publicly available through open access. This may include open sharing of research outcomes, peer-reviewed articles and access to software, models, algorithms, workflows, etc. Openly sharing your data is thus only not limited to publishing in open access journals or platforms, but also about boosting innovation and creating greater societal impact. By choosing the appropriate license, you can still retain intellectual property rights.

Before you publish your data, it is best that you appraise your data, attach a license, and select a fitting repository. In this appraisal, you need to document and preserve everything that is needed to verify and/or replicate your study. **Data that cannot be completely anonymized cannot be deposited in an open access repository**. It is recommended to choose a trusted repository, whereby your data obtain a persistent and unique identifier.

Research data repositories

A research data repository is a database infrastructure for managing, storing and disseminating research data. It allows you to search for data based on the attached metadata.[80]

Research data repositories exist in all shapes and sizes. To easily select the most suitable research data repository for your research data, you can find an overview per research discipline on this page on the VUB SharePoint.

Tool 21 – Open Science starter guide

The Open Science Office at VUB is coordinating Open Science policies and activities. The Open Science Office advises on strategic issues and priorities, works on practical solutions within the university, and engages with the academic community around Open Science.

On the VUB SharePoint, you can find more information about open science policies and resources. Join the open science movement, and check the Open Science Starter Guide online! For more specific questions, you can contact openscience@vub.be.

Further resources:

- This training guide "Understanding data repositories: A beginners' guide for researchers & data stewards" explains the basics of data repositories: what is the difference between a data repository and an archive? What are the different types of repositories? How can data in repositories apply FAIR principles? A similar guide is "Understanding Metadata: A beginner's guide for researchers & data stewards", explaining the basics of metadata. Both guides are published by the EUTOPIA European University, Research Data Management & Open Science Community at the Vrije Universiteit Brussel.
- This short guide 'Open Science in Horizon Europe' introduces the open science requirements of the Horizon Europe programme. It explains mandatory and recommended practices and gives practical examples. The guide was developed with the support of the EUTOPIA-TRAIN project, an initiative of the EUTOPIA European University. Furthermore, on the OpenAIRE website, you can find more specific information about how to comply with open science principles within Horizon Europe proposals. The European Research Council partly deviates from the default Open Science layout for the evaluation of its proposals.

- With the research and the generation of knowledge, your research project can contribute to the UN Sustainable Development Goals (SDG). The collected citizen science data can help monitor the SDG indicators, often with a higher level of granularity and at a lower cost in comparison to traditional data sources. If citizen science data is published in line with FAIR principles, then they can be a new resource for specific indicators. Get inspired by the following examples:
  - » This article from Fritz et al. (2019) presents a roadmap that outlines how citizen science can be integrated into the formal Sustainable Development Goals reporting mechanisms.
  - » This article from Fraisl et al. (2020) maps the citizen science contributions to the UN Sustainable Development Goals.
  - » The following report published by the European Commission (2018) developed an EU-wide inventory with an evidence base about how citizen science can support environmental policies in the EU.

Evaluate your research project

In this step, you evaluate the success and effectiveness of your citizen science research project. The assessment, either process-based or outcome-oriented, can take place at the beginning of your study, half-way, or at the end of it. An evaluation at the start of your research project can help to identify the participants' expectations, and this will enable you to make early adjustments to the project design. With this baseline, you can periodically evaluate the project against a predefined set of metrics and, if necessary, apply any deviation mechanisms. An evaluation in the live phase of the project can provide an impulse for change. If you solely perform an end evaluation, you will be able to understand what worked and what went wrong, but without tracking any process of change.

Performing an assessment of your citizen science research can offer many benefits[81]:

- You acquire new ways of thinking and understanding, or new attitudes about certain practices. For instance, you gain deeper understanding about the importance of the data collection protocol.
- You can take direct action or decisions to improve activities, for instance when evaluation reveals that too many participants drop out due to jargon.
- You can use the evaluation outcomes to legitimize, justify or convince others, for instance to convince funders or external financiers of the impact of citizen science.
- You are actively involved in the development and implementation activities, and therefore gain a better understanding about the participants' efforts.

It is best to do an evaluation with the entire project team. Every partner shares its perspective and can reflect on the objectives and results achieved. It is also recommended that you draw up several indicators that you will monitor and evaluate. These indicators can be both qualitative and quantitative and can serve different purposes. Your evaluation can focus on the success of the citizen science project by evaluating the (intermediate) outcomes, the operational processes, the engagement strategy, etc. When your research project is up and running you will get a better feel of the type of indicators you wish to monitor. Allow for adequate flexibility in your evaluation and add or modify indicators as you go along.

Tool 22: MICS

Through the MICS (Measuring the Impact of Citizen Science) platform you can assess the impact of your citizen science project through metrics and indicators across different domains: society, economy, environment, science and technology, and governance.

You receive an individualized score and can compare the outcome with similar projects.

The tool is available via the MICS platform, and you can read more about the underlying impact domains and indicators in this scientific publication by When et al. (2021).

Tool 23: CSISTA Impact Inquiry Instrument

To capture success stories of citizen science in relation to policy and decision making, the WeObserve project developed the CSISTA approach, or the Citizen Science Impact Story Telling Approach.

By using the following template, you can collect qualitative information necessary for the creation of an impact story.

Tool 24: Evaluating learning outcomes

The Cornell Lab of Ornithology created a toolkit to measure participants' learning outcomes, such as interest, motivation, self-efficacy for learning and doing science, skills for scientific inquiry, etc. A set of evaluation instruments, with specific scales, is available on request through the following website – together with a user guide.

These instruments were developed in the DEVISE project (Developing, Validating, and Implementing Situated Evaluation Instruments Project).

Further resources:

- This article of Schaefer et al. (2021) provides an overview of the diversity of the citizen science evaluation approaches, explained through a few case studies.
- Kieslinger et al. (2018) developed a citizen science evaluation framework with three dimensions: scientific, participant and socio-ecological and economic. Each dimension is operationalized through a set of criteria and supporting questions.
- In the state-of-art of Somerwill & When (2022) an overview is provided of how to measure the impact of citizen science on environmental attitudes, behaviour and knowledge.

Phase 5

Sustain

This is the final stage of your citizen science research project.

In this phase, you reflect on whether you would like to continue with the citizen science activities in the long run, and how you can fully exploit the research results. You can write a valorisation plan about the outcome, financial and community sustainability of your research.

Citizen science in the long run

After you finish your citizen science research project, it might be that there is still an interest from your side or the community to continue.

In this regard, there are some questions you need to consider:

- Will we repeat this project, and with which frequency (e.g. annually)?
- Should we develop a follow-up project with a different focus?
- How can the project be kept alive in the community?
- Can the project be linked to other (future) projects?
- Who will take care of the citizen science tools (e.g. sensors) and their maintenance?
- Should we apply for extra funding?

It is not always necessary to write a long-term plan for a citizen science project. A one-off initiative may be sufficient to answer your research questions. The advantage of writing out a vision for the long term is that projects can be better aligned, expertise from multiple services can be bundled, and there is a constructive collaboration between knowledge institutions and citizens.

Case study: Curious Noses

CurieuzeNeuzen (Curious Noses) is an example of a citizen science project with long-term planning. Their first measurement campaign started in 2016, focusing on measuring air quality in Antwerp. In 2018, they repeated this measurement campaign for the whole of Flanders, and later also in the Brussels-Capital-Region. After that, the measurement campaigns got a new thematic focus, i.e. heat stress in private gardens.

The advantage of having long-term planning is that the same platform can be re-used, and subsequently extended with more advanced features, as well as having a growing contact base of citizen scientists who like to participate.

Curious Noses is coordinated by the University of Antwerp, with the support of other academic partners (VITO), the media (De Standaard) and governmental partners (VMM, Departement Omgeving, Departement Economie, Wetenschap & Innovatie), and also private companies (Orange, DPD, Aquafin, Bio-Planet & Natuurpunt).

You can find more information about this project on their website.

Valorising research for society

At the end of your research project, you try to maximize the transformation of research and innovation results into solutions that benefit society. The collected data, know-how and research results can be valorised into sustainable products, services, solutions, or knowledge-based policies.

The valorisation of these outputs can be guided by open science principles, whereby you promote the broad dissemination of your publications, collected data, databases and software through open access publishing. If your research project pursues a commercial objective, it is advised that you look into intellectual property rights, such as patents and trademarks.

With regards to sustainability of your citizen science research project, you can reflect on its outcome, community, and financial sustainability[82]. Depending on your set-up and chosen objectives, the way you keep the research project sustainable will look different:

- The **outcome sustainability focusses** on keeping the results of your research project available for future usage.
- The **community sustainability** focusses on supporting the community of citizen scientists after the project's ending, in case there is an interest or need for further data collection.
- The **financial sustainability** focusses on finding the necessary monetary resources for keeping the project up and running.

Tool 25 – How to make your citizen science research (project) sustainable

Use the following template, developed by the Citizen Science Contact Point of the VUB, to reflect about the outcome, community and financial sustainability of your research (project).

Please contact citizenscience@vub.be if you have any further questions, or if you need personalized support.

Further resources:

- The VUB Tech Transfer brochure: it provides information about knowledge and technology transfer through the creation of spin-offs, the licensing of intellectual property, contract research, etc.
- Keep an eye on the 'Community of practice on citizen engagement for knowledge valorisation' which will publish a guide on principles and recommendations for knowledge valorisation by the end of 2023.
- You can watch this webinar, from the ACTION project, on citizen science and financial sustainability.
- If you apply for European funding, you can receive free advice on how to boost the exploitation potential of your research results through the Horizon Result Booster programme.
- This handbook from the European Commission provides a good overview on the impacts of open innovation and open science.

Endnotes

Module 1

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