Participatory science and Data Visualization for Social Purposes

About the course

The general objectives of this course are to understand and resolve (1) conceptual problems in the domain of participatory (citizen) science and (2) related problem situations in digital environments for data analysis and reporting for social purposes.

This upskilling short course is thus aligned with:

- **DIGCOMP 2.2:** Competence area 5. Problem solving (Competence 5.3 Creatively using digital technologies)
- **ESCO v1.1.1. S5.6.0:** using digital tools for collaboration, content creation and problem solving (http://data.europa.eu/esco/skill/cacc62f3-2df4-4cc3-9d5d-0d014db56bd9)

Course enrolment requirements and entry competences required for the course

- Basic understanding of simple digital tools and technologies (e.g. Office, social media).
- Interest in conceptual problems and problem situations in digital environments.

Learning outcomes expected at the level of the course

- Engage in collaborative processes to support and enhance citizens' participation in society using digital technologies and platforms.
- Understand that technology has the potential to be used for social purposes (e.g. in support of citizen science activities).
- Identify online platforms that can be used to design, develop and test visualizations of open or proprietary data.
- Design a digital story using Tableau Public.

Course content

Hybrid lecture: introduction to the course (2 hours)

Part 1: Citizen Science: from a learner to a "producer"

1.1. What is Participatory science or Citizen Science? (2 hours)

"Participatory science is an expansive field where the public contributes to scientific knowledge and understanding. A variety of terms are used to describe this valuable work including citizen science, community science, volunteer monitoring and public participation in scientific research. … Participatory science uses the collective strength of communities and the public to identify research questions, collect and analyze data, interpret results, make new discoveries, and develop technologies and applications – all to understand and solve problems." (EPA, 2023)[1]

What is Citizen Science?

https://www.youtube.com/watch?v=a-Jlo4MgNMo

[1] EPA (2023) Participatory Science at EPA: Engaging the Public in Environmental Protection, 2023, https://storymaps.arcgis.com/stories/57b2ee78221341a18b0f7ebe8017340d

Citizen Science Starter Kit

The starter kit is an Open Educational Resource (OER) developed by Veeckman, Keersmaekers, Verbrugge & Livémont (2022)[2] within the EU project EUTOPIA-TRAIN. It consists of different modules, all of which are adapted and presented as a part of this course.

What is citizen science?

Citizen science is often used as an umbrella term to describe a wide range of participatory activities. Citizen science is also known as community science, crowd science, civic science, crowdsourcing, volunteer monitoring, volunteered geographic information, etc. This makes it rather challenging for practitioners who are new to the field to understand what citizen science is about. In the last decades, we have witnessed a rapid growth of citizen science (projects) in all scientific branches and disciplines. Societal and technological changes have allowed citizens to contribute more to science. Furthermore, citizen science is also receiving increasing attention from policymakers who are launching specific 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[3].

The rise of citizen science

Citizen science was mentioned in the literature for the first time in the 1990s by Rick Bonney (US, ornithologist) and Alan Irwin (UK, sociologist). Bonney's concept of citizen science is nowadays more relevant than Irwin's. In their study on Public Participation in Scientific Research (PPSR) in 2009[4], Bonney et al. described citizen science as an approach for cost-effective data collection and for building public science literacy. In this publication, the term citizen science is rarely used, and they referred to PPSR instead.

However, the term 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'. In the 18th century, they were performing research from their living rooms before any formal academic institution existed. For instance, in Germany in 1786, Caroline Herschel discovered comet 'Caroline', by studying the skies on her own[5].

In this course, we use the following definition: *"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)*[6]

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.

Amongst the multiplicity of definitions, the European Citizen Science Association (ECSA) provides some guidance to practitioners with regard to fundamental principles which are expected of a good citizen science project. 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 projects.

10 principles of citizen science[7]

1. Citizen science projects actively involve citizens in the scientific endeavour that generates new knowledge or understanding. Citizens may act as contributors, collaborators, or as project leaders 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 professional scientists and citizen scientists benefit from taking part. Benefits may include the publication of research outputs, learning opportunities, personal enjoyment, social benefits, satisfaction through contributing to

[2] Veeckman, Carina, Keersmaekers, Floor, Verbrugge, Karel, & Livémont, Eline. (2022). D3.3 Citizen Science Starters Kit (Online Citizen Science Training Materials) (Version 2). Zenodo. https://doi.org/10.5281/zenodo.7014861

[3] https://www.academia.edu/40004431/The_problem_with_delineating_narrow_criteria_for_citizen_science

[4] Bonney, R., Ballard, H., Jordan, R., McCallie, E., Phillips, T., Shirk, J., & Wilderman, C. C. (2009). Public Participation in Scientific Research: Defining the Field and Assessing Its Potential for Informal Science Education. A CAISE Inquiry Group Report. Online submission.

[5] Gijsel, L., Huyse, T., & Van Hoyweghen, I. (2019). *Citizen science: Hoe burgers de wetenschap uitdagen*. Uitgeverij Pelckmans.

[6] https://dictionary.cambridge.org/dictionary/english/citizen-science

[7] https://zenodo.org/record/5127534#.Yrxh1-xBzzK

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 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 the opportunity for greater public engagement and democratisation of science.
7. 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.
8. Citizen scientists are acknowledged in project results and publications.
9. Citizen science programmes are evaluated for their scientific output, data quality, participant experience and wider societal or policy impact.
10. 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.

Out of a need to further address the ambiguity in the field, ECSA and partners of the EUCitizen.Science project have set up a working group which developed a set of characteristics of citizen science (based on the 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.

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

- Citizen science is not equal to science communication. In citizen science research, the public actively participates in the research and is no longer solely the target of science communication. The public is also 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 to be citizen science.

✍ Share your thoughts and opinions - Time for reflection:

- 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 give an example of a project which is not defined as citizen science?

[8] Walls TA, Coria A, Forkus SR. Citizen Health Science: Foundations of a New Data Science Arena. Int J Popul Data Sci. 2019 Sep 26;4(1):1074. doi: 10.23889/ijpds.v4i1.1074. PMID: 32935026; PMCID: PMC7299478.

✍ Is this citizen science or not?[9]

1) On FixMyStreet, citizens can report incidents in public spaces (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, in Lewistown, Montana, USA. Her work is emotionally demanding, and she has discovered that watching birds helps her maintain her wellbeing. As a person new to birding, she is using a bird observation recording app on her phone. The app allows her to maintain a checklist of the 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 studying at a high school in Trento, Italy. During a visit to the local history museum, he spends time at an interactive exhibit that shows him the different mammal species in the area, which were photographed with camera traps. The exhibit encourages visitors to identify them, giving a score at the end. The exhibit was designed by the museum's experts, and the data from the different interactions is not stored or used beyond statistics on how long sessions last, and how many visitors have used it.[11] Is this citizen science or not?
5) Ella is a web designer and is interested in a healthy lifestyle and technology. She uses the TopFit smartwatch to collect her biodata throughout the day to monitor and reach personal health and fitness goals including exercise, sleep, weight and more. She also shares her data with the TopFit community and sometimes participates in TopFit challenges. She pays a subscription fee and receives notifications, personal data dashboards or tips. She often follows the advice and has changed her routines accordingly.[12] Is this citizen science or not?

Terminology matters[13] – the words that we use for what we observe or what we describe can matter greatly to people. 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 sense, this course opts 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 from the article by Eitzel et al. (2017) illustrates the commonly used names to describe people who participate in citizen science. Every term is explained and interpreted in a different (negative) way:

[9] Number 3 and 4 are recognized as citizen science.

[10] From the vignette study of Muki Haklay, Dilek Fraisl, Bastian Greshake Tzovaras et al., Contours of citizen science: a vignette study (Royal Society, 2021)

[11] From the vignette study of Muki Haklay, Dilek Fraisl, Bastian Greshake Tzovaras et al., Contours of citizen science: a vignette study (Royal Society, 2021)

[12] From the vignette study of Muki Haklay, Dilek Fraisl, Bastian Greshake Tzovaras et al., Contours of citizen science: a vignette study (Royal Society, 2021)

[13] Eitzel, M.V. et al., 2017. Citizen Science Terminology Matters: Exploring Key Terms. *Citizen Science: Theory and Practice*, 2(1), p.1. DOI: http://doi.org/10.5334/cstp.96

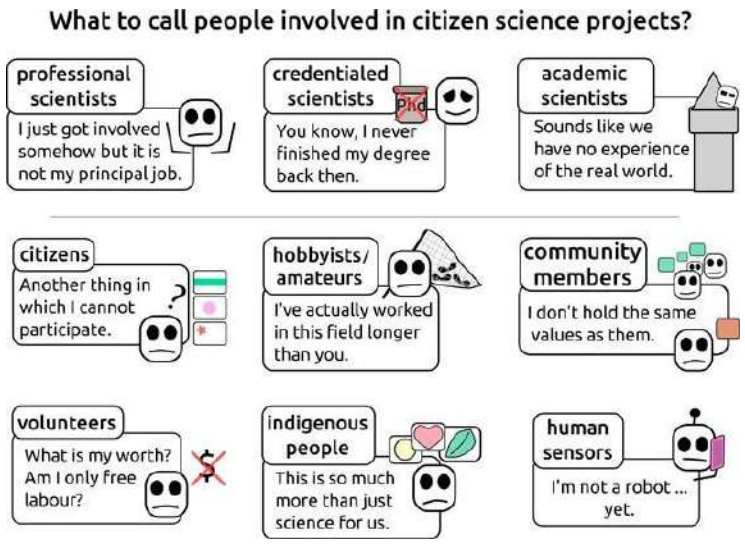

Figure: What to call people involved in citizen science projects. Illustrated examples by Eitzel et al. (2017).

Benefits of citizen science

Citizen science can yield a variety of benefits and outcomes. Benefits can occur at an individual level or at the larger science-society interface. Benefits for scientists and citizens are mainly formulated as individual benefits, while societal benefits are formulated for society as a whole. From the individual participant's perspective, benefits can be related to, for instance, increased topical knowledge, while on the societal level, this can be related to political and environmental types of benefits. 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 the research.

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

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

Benefits for science

We start by listing the benefits for science. Citizen science can yield individual benefits and outcomes for *scientists* in the following ways:

- Increased research capacity: One of the main reasons why scientists 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 the research, you can add lay, local and traditional knowledge to scientific knowledge. Citizen science can thus 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), which might allow 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 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 scientists and citizens: Citizen science equals collaboration. When citizens are involved in science, mutual understanding can be created between citizens and scientists. 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 (scientists)	• Increased research capacity • Newly acquired data and information • More innovative research
Societal level	• More societally relevant research • Bridging the gap between scientists and science • Diversity in science

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

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 your knowledge about science, but also about the topic. 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 specifically the case for projects related to environmental topics, whereby an increased awareness and support for certain themes can occur (e.g. air quality, mobility, etc.). Furthermore, raised awareness is known to correlate with environmental stewardship. Citizens can hereby gain "a 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 the research.

On a broader societal level, citizen science can generate the following benefits on the political and environmental levels:

- Political benefits: Firstly, the data collected in citizen science projects can help to inform, decide and follow up on policies, which can make them more societally relevant. Citizen science can provide an evidence base for data-driven policymaking. Furthermore, by involving

[14] Goudeseune, L., Eggermont, H., Groom, Q., Le Roux, X., Paleco, C., Roy, H.E., van Noordwijk, C.G.E. (2020). BiodivERsA Citizen Science Toolkit For Biodiversity Scientists. BiodivERsA report, 44 pp.

[15] Hecker, S, et al. 2019. How Does Policy Conceptualise Citizen Science? A Qualitative Content Analysis of International Policy Documents. Citizen Science: Theory and Practice, 4(1): 32, pp. 1–16. DOI: https://doi.org/10.5334/cstp.230

[16] Queiruga-Dios, MÁ, López-Iñesta, E, Diez-Ojeda, M, Sáiz-Manzanares, MC, Vázquez Dorrío, JB. Citizen Science for Scientific Literacy and the Attainment of Sustainable Development Goals in Formal Education. *Sustainability*. 2020; 12(10):4283. https://doi.org/10.3390/su12104283

[17] Jordan, R., Gray, S., Howe, D., Brooks, W., & Ehrenfeld, J. (2011). Knowledge gain and behavioral change in citizen-science programs. Conservation Biology, 25(6), 1148–1154. https://doi.org/10.1111/j.1523-1739.2011.01745.x

citizens in decision-making processes, it can result in greater acceptance and support for important policy themes. The data gathered in citizen science can eventually also impact policies and institutions.

- Environmental benefits: Citizen science projects can also lead towards improved environments or livelihoods, and often have a cross-over with the implementation of nature-based solutions. For instance, citizen science research can help to identify polluters or exotic threatened species or can help to reinforce tougher environmental policies, laws or regulations with evidence-based data.

	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 and livelihoods

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

The citizen science landscape

Citizen science projects can be organized within many scientific branches and disciplines. To showcase diversity, this section describes citizen science practices in various disciplines. Some scientific disciplines already have a long-standing tradition with citizen science, while others are just at the beginning.

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[22]. 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.

Furthermore, nowadays 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. These monitoring projects mainly invite citizens to collect data by counting species such as counting birds or butterflies. The best-known examples of citizen science in Flanders perform(ed) in the natural sciences are focused on biodiversity, mobility and air quality.

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

[18] Lea Den Broeder, Jeroen Devilee, Hans Van Oers, A Jantine Schuit, Annemarie Wagemakers, Citizen Science for public health, *Health Promotion International*, Volume 33, Issue 3, June 2018, Pages 505–514, https://doi.org/10.1093/heapro/daw086

[19] Hecker, S, et al. 2019. How Does Policy Conceptualise Citizen Science? A Qualitative Content Analysis of International Policy Documents. Citizen Science: Theory and Practice, 4(1): 32, pp. 1–16. DOI: https://doi.org/10.5334/cstp.230

[20] Veeckman, C., Van Herck, B., Carpentier, M., Van Laer, J. & Sterken, M., (2021). Citizen Science Roadmap for Local Government. A hands-on manual for citizen science, by and for cities and towns. SCIVIL, Leuven, Belgium.

[21] Walker, D. W., Smigaj, M., & Tani, M. (2021). The benefits and negative impacts of citizen science applications to water as experienced by participants and communities. *Wiley Interdisciplinary Reviews: Water*, *8*(1), e1488.

[22] Frigerio, D., Richter, A., Per, E., Pruse, B., Vohland, K. (2021). Citizen Science in the Natural Sciences. In: K. Vohland et al. (eds.), *The Science of Citizen Science,* 79. https://doi.org/10.1007/978-3-030-58278-4_5

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 thus 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. More about this project: https://stadtwildtiere.ch/

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.

For instance, examples of mathematical projects that have adopted aspects of citizen science can be found in collective problem-solving and distributed computing[23]. The former projects are focusing on online collaboration between mathematicians who help 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 for assisting or replacing 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)[24]. 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 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 recognise the disorder, paving the way for screening by artificial intelligence. As such, the citizen scientists are helping to build up a reference database of annotated images, which can be used to train an AI software to recognise diabetic retinopathy in future. This project clearly exemplifies the cross-over between the formal sciences and health research. More information: https://www.oogvoordiabetes.be/

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[25]. Typologies in the citizen humanities have been proposed to classify the activities and 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

[23] Hartkopf, A. M. (2019). Developments towards Mathematical Citizen Science. In *Forum Citizen Science 2019*.

[24] Ceccaroni, L., Bibby, J., Roger, E., Flemons, P., Michael, K., Fagan, L. and Oliver, J.L., 2019. Opportunities and Risks for Citizen Science in the Age of Artificial Intelligence. *Citizen Science: Theory and Practice*, 4(1), p.29. DOI: http://doi.org/10.5334/cstp.241

[25] Heinisch, B., Oswald, K., Weißpflug, M., Shuttleworth, S., Belknap, G. (2021). Citizen Humanities. In: K. Vohland, et al. (eds.), *The Science of Citizen Science*, 97. https://doi.org/10.1007/978-3-030-58278-4_6

provided by the citizens themselves[26]. Citizens often perform tasks that include curating, transcribing, or annotating artefacts.
Many projects have been taking place in the arts and humanities, and 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.

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.

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 which involves participants in a social sciences research project[27], 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[28].
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 since 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[29]. 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 was looking 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. About this project: https://www.rivm.nl/gezonde-leefomgeving/kijk-gezonde-wijk-watsap-project

Other examples:

[26] Heinisch, B., Oswald, K., Weißpflug, M., Shuttleworth, S., Belknap, G. (2021). Citizen Humanities. In: K. Vohland, et al. (eds.), *The Science of Citizen Science*, 97. https://doi.org/10.1007/978-3-030-58278-4_6

[27] Purdam, K. 2014. Citizen social science and citizen data? Methodological and ethical challenges for social research. *Current Sociology*, 62(3): 374–392. DOI: https://doi.org/10.1177/0011392114527997

[28] Tauginienė, L., Butkevičienė, E., Vohland, K. *et al.* Citizen science in the social sciences and humanities: the power of interdisciplinarity. *Palgrave Commun* 6, 89 (2020). https://doi.org/10.1057/s41599-020-0471-y

[29] Fischer, A., Dinnie, E., Ellis, R., Eastwood, A., Carter, A. and Welsh, G., 2021. Exploring the Potential of Citizen Social Science for Environmental and Sustainability Research: Experiences of and with Community-Based Researchers. *Citizen Science: Theory and Practice*, 6(1), p.17. DOI: http://doi.org/10.5334/cstp.389

- 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.
- 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

1.2. What constitutes a good citizen science project? (2 hours)

Citizen science does not fit 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 the research (project) or if you want to engage with some ongoing citizen science projects. Several situations are described which lead to shared benefits in citizen science, with helpful examples in the various scientific disciplines.
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. In the right circumstances, citizen science may be very beneficial. In other circumstances, it may be that other ways to engage the public are more suited.
Several decision-making factors are described to help you decide whether citizen science is a viable option either for your project or if you are considering engaging in one:

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

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 nowadays towards pursuing public engagement in the university, in specific departments and of individual researchers? Is it practically achievable, and which processes need to change for supporting it? Which capacities are needed, and what are the potential obstacles?
For conducting citizen science projects, we highlight the following questions to assess the readiness level of citizen science stakeholders:

- To what extent do you have an open attitude towards collaborating with citizens? Are you willing to listen to their ideas and *actively* use the information for the research?
- To what extent would you trust the information collected by citizens?
- To what extent are you open to sharing power and ownership over the scientific process and developing a mutual relationship between scientists and citizens?
- To what extent are you flexible in adapting the research process based on the collected findings?
- How do you feel about openly sharing the research data?
- To what extent can you be open and transparent about the scientific process?
- Do you have the necessary capacities to support public participation in research?

Applying citizen science might thus come with a change in working habits, operational processes, and hierarchies. The extent of it is dependent on the type of citizen science project. 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 also data-related challenges (e.g. data quality)[30].

 Reading tips:

- 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 cocreation. 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.

The importance of engagement

In addition to the readiness level, you should also consider how important engagement is for the research (project). Participants can be engaged in research for a wide range of activities, throughout the whole 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
• 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 • ….
Analyse data	**Report & disseminate**	
• Annotating • Transcribing • Interpreting • Calculating • ….	• Proposing new directions for research • Co-authoring a publication • Speaking at a public event • Becoming a project ambassador • …	

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

Apart from activities in the scientific research process, there are also tasks related to the research design and project management. Activities related to the research design and project management refer to developing training materials, establishing a network of participants, organizing communication and support mechanisms, holding meetings and events, etc. Although these tasks are mostly performed by the research team, citizen scientists are also involved in these implementation tasks in some projects. This is often the case in research (projects) with a high level of citizen involvement. Regardless of the activity participants are performing, it should be ensured that they are engaged in an *active, meaningful* way[31]. They are involved in the research as co-designers and implementers of research tasks, and not as

[30] European Commission (2020). *Best Practices in Citizen Science for Environmental Monitoring*. COMMISSION STAFF WORKING DOCUMENT SWD (2020) 149 final; p. 76.

[31] Pocock, M.J., Chapman, D.S., Sheppard, L.J., & Roy, H.E. (2014). Choosing and using citizen science: a guide to when and how to use citizen science to monitor biodiversity and the environment.

a research objects. 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.

 Reading tips:

- 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. Think of your Bachelor/Master research project and answer these questions:

- 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, without the need to try to make it a citizen science project?
- 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?

Transdisciplinary research
Citizen science is highly suited to creating connections beyond the discipline-specific approach. You can constitute a research team by combining different scientific disciplines, with researchers from different faculties. Interdisciplinary environments challenge researchers to work together to reach a common goal, find a common vocabulary and share knowledge. At the European level, Research & Development programmes are calling for higher interdisciplinarity, as a way to come up with quicker and more effective solutions to wicked problems[32].
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[33]:

- 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.

 Reading tips:

[32] https://ec.europa.eu/info/sites/default/files/research_and_innovation/groups/rise/allmendinger-interdisciplinarity.pdf
[33] Veeckman, C., Van Herck, B., Carpentier, M., Van Laer, J. & Sterken, M., (2021). Citizen Science Roadmap for Local Government. A hands-on manual for citizen science, by and for cities and towns. SCIVIL, Leuven, Belgium.

- The social sciences and humanities (SSH) are gaining more acknowledgement within interdisciplinary citizen science projects. The liaison emerges through the need to learn more about the social dimensions of the research and to provide a framework for engagement. Read more about the inclusion of SSH in this article.

The spatial and temporal scale

Citizen science is highly suitable if you need to collect or analyse data across large spatial scales over longer periods of time. It is one of the main decision-making factors in 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[34]. For this reason, we see many citizen science projects in the field of environmental monitoring. Citizen science allows increases and improvements in research data and the gathering of data that otherwise would not have been normally available (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[35].

 Reading 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.

The amount of data that needs 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[3637]. 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[38]. Other potential game elements are badges, listing top contributors of the week, unlocking

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[34] Kaartinen, R., Hardwick, B., & Roslin, T. (2013). Using citizen scientists to measure an ecosystem service nationwide. *Ecology*, *94*(11), 2645-2652.

[35] König, Ariane et al. 'Can Citizen Science Complement Official Data Sources That Serve as Evidence-base for Policies and Practice to Improve Water Quality?' 1 Jan. 2021: 189 – 204. https://content.iospress.com/articles/statistical-journal-of-the-iaos/sji200737

[36] Ceccaroni, L., Bibby, J., Roger, E., Flemons, P., Michael, K., Fagan, L. and Oliver, J.L., 2019. Opportunities and Risks for Citizen Science in the Age of Artificial Intelligence. *Citizen Science: Theory and Practice*, 4(1), p.29. DOI: http://doi.org/10.5334/cstp.241

[37] Ponti, M., Seredko, A. Human-machine-learning integration and task allocation in citizen science. *Humanit Soc Sci Commun* 9, 48 (2022). https://doi.org/10.1057/s41599-022-01049-z

[38] Greenhill, A., Holmes, K., Woodcock, J., Lintott, C., Simmons, B.D., Graham, G., Cox, J., Oh, E.Y. and Masters, K. (2016), "Playing with science: Exploring how game activity motivates users participation on an online citizen science platform", *Aslib Journal of Information Management*, Vol. 68 No. 3, pp. 306-325. https://doi.org/10.1108/AJIM-11-2015-0182

levels, group missions, etc. These elements work very well for younger age groups and extrinsically-driven participants[39].
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.

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/

The complexity of the data protocol
The complexity of the data protocol can be 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 the data protocol as easy as possible. The easier participants can collect data, the more likely they 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. The data protocol worked in the following manner. It was decided that the Zooniverse platform would be used to annotate a dataset of retinal images. Therefore, 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 to the participants 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 particularly suited to citizen science projects. However, you need to be aware that only a particular profile, and most often an expert profile, will participate (e.g. naturalists, hobbyists, medical professionals, 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 to ensure that the data is correctly collected or analysed.

 Reading 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.

[39] Bowser, A., Hansen, D., Preece, J., He, Y., Boston, C., Hammock, J. (2014). Gamifying citizen science: A study of two user groups. Proceedings of the Companion Publication of the 17th ACM Conference on Computer Supported Cooperative Work & Social Computing - CSCW Companion '14, 137–140. https://doi.org/10.1145/2556420.2556502

The template below can help you make design choices for your data protocol[40]:

- Location - Are the participating citizens completing the tasks online (e.g. via Zooniverse), on-site (e.g. in the garden), or combined? Does the task need to be completed at one particular site or on a large spatial scale? Do participants have access to these sites?
- Frequency & timing – Are participating citizens completing the tasks for a one-time event or regularly? What is the desired frequency? Does the task need to be repeated on a seasonal basis?
- Citizen science tools - Which tool is the citizen using to complete the task? Is it a digital tool or another form (e.g. sensors, smartphone applications, websites, measurement kits, paper forms, etc.)? Is the tool easy to use? Is the tool freely available?
- Efforts – How much time does it take for a citizen to complete a task? Is the task too demanding for the citizen? Does the frequency encourage participation?
- Citizens' skills and knowledge – Does the task match the skills and knowledge of the citizens? Is there a possibility to advance the type of tasks over time?
- Training and support: Is it necessary to publish a how-to guide? Is it necessary to organise a training session (on-site, or online)?
- Data quality – Which validation mechanisms can be provided to ensure data quality (e.g. request response, validation by expert users, number of entries, fixed drop-down menus, etc.)?

 Reading tips:

- This guidebook 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.
- 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.

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. Training can be organized in person or online, with supervision also during the data collection. Training and the establishment of a protocol are vital for ensuring data quality. Personnel costs will also be dedicated to communication and awareness-raising activities. Communication is a vital aspect of 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.

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[40] Based on info published in: 1) Mondardini, Maria Rosa; Roffler, Ursina; Eliseeva, Tatiana; Höhener, Olivia; Kretzer, David Michael; Lenart-Gasiniec, Regina; Maatz, Anke; Martin, Mike; Tönsmann, Susanne; Tsianou, Evgenia; Wiederkehr, Stefan (2021). *Practicing Citizen Science in Zurich: Handbook.* Zürich: Citizen Science Center Zurich, and 2) Pocock, M. J., Chapman, D. S., Sheppard, L. J., & Roy, H. E. (2014). *Choosing and Using Citizen Science: a guide to when and how to use citizen science to monitor biodiversity and the environment*. NERC/Centre for Ecology & Hydrology.

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 the 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 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, 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.

 Reading tips:

- This thesis researches the cost savings of citizen science projects by comparing three projects with their professional equivalent.
- This article 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 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.

✍ Time to reflect – share your thoughts and opinions:

- Read this opinion piece by Dr. Paul Drachman on 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. What is your opinion on this?
- How do we guarantee that research involving citizen scientists does not discontinue quickly after the project ends?

Typologies of citizen science projects

There are several typologies which classify citizen science projects. We discuss typologies based on the degree of participation and the primary project goal. The most commonly used typology by citizen science practitioners is based on the different degrees to which participants are engaged in the scientific process. These models stem from the broader field of Public Participation in Scientific Research (PPSR), which covers different forms of citizen involvement in research. The degree of participation is defined as the extent to which citizens are involved in the process of scientific research[41]. Based on the degree of participation, there are five models[42]:

Type	Description	Example
Contractual	Citizens ask professional scientists to conduct a specific scientific investigation. Citizens can exert a control over the research agenda and the resulting knowledge produced. However, further	The 'Science Shop' is a project of the VUB, the University of Antwerp and the KU Leuven. It is an example of a contractual project, whereby notfor-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.

[41] Shirk, J. L., Ballard, H. L., Wilderman, C. C., Phillips, T., Wiggins, A., Jordan, R., ... & Bonney, R. (2012). Public participation in scientific research: a framework for deliberate design. *Ecology and society*, *17*(2).

[42] Shirk, J. L., Ballard, H. L., Wilderman, C. C., Phillips, T., Wiggins, A., Jordan, R., ... & Bonney, R. (2012). Public participation in scientific research: a framework for deliberate design. *Ecology and society*, *17*(2)

	participation in the remainder of the research process is limited.	
*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 VespaWatch, 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 were to collaborate in the first phase of the project with volunteers from the Stadslab 2050 group. They and the volunteers 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 designed by scientists and citizens. The question or issue is defined by the public. All of 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 around the table to consider study areas and solutions for environment-related challenges like air pollution, drought, flooding, lack of greenery, and heat. In 2019 they began work on the subject of heat stress.
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 fab labs, or hobby clubs for instance.

*Table: 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)* [43]

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. The three middle models in the table, which clearly demonstrate a range of public participation activities in scientific research, align closely with models defined by other scholars. Although authors are using different labels for their models, the projects are all categorized according to the degree of participation – regardless of the field of practice. For instance, Haklay also defined a common-known typology based on the level of participation and engagement in citizen science projects[44]:

Type	Description	Example
Crowdsourcing	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. Research has been done in areas such as childhood cancer. 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 pa-

[43] Bonney, R., Ballard, H., Jordan, R., McCallie, E., Phillips, T., Shirk, J., & Wilderman, C. C. (2009). Public Participation in Scientific Research: Defining the Field and Assessing Its Potential for Informal Science Education. A CAISE Inquiry Group Report. *Online submission*.

[44] Haklay, M., 2013, Citizen Science and Volunteered Geographic Information – overview and typology of participation in Sui, D.Z., Elwood, S. and M.F. Goodchild (eds.), 2013. Crowdsourcing Geographic Knowledge: Volunteered Geographic Information (VGI) in Theory and Practice. Berlin: Springer. pp 105-122 DOI: 10.1007/978-94-007-4587-2_7

		tients 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 recognise 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 researcher 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: 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[45]. 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 to 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 the research (project); you can also facilitate multiple levels. Citizens will inherently create their own individualized experience, regardless of the predominant model of participation in the project. As such, you might have a core group of participating citizens who are engaged in all stages of the process, while the majority only contribute with data collection or creation.
- You can modify your project design throughout 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.

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[46]:

Type	Description	Example
Action	This project is 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.

[45] Hecker, S., Bonney, R., Haklay, M., Hölker, F., Hofer, H., Goebel, C., Gold, M., et al. (2018). "Innovation in Citizen Science - Perspectives on Science-Policy Advances.". Citizen Science: Theory and Practice, vol. 3, nr. 1, pp. 1–14.

[46] Wiggins, A., & Crowston, K. (2011, January). From conservation to crowdsourcing: A typology of citizen science. In *2011 44th Hawaii international conference on system sciences* (pp. 1-10). IEEE

Conservation	These projects are mostly initiated by researchers or by governmental actors. They are primarily focused on data collection for resource management decision-making, and with 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) 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 with educational materials for the public. They often operate on a larger physical scale.	The citizen science project 'Stiemerlab' starts from the premise that citizens of Genk, residents and local organizations 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 to 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 to focus 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 EastFlanders (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 allowed 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 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.

 Reading tips:

- Based on the formerly mentioned typologies of Bonney et al., Shirk et al., and Wiggens and Crowston, this article 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. 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.

✍ Time to reflect – share your thoughts and opinions:

- What is or are the different degrees of citizen participation?
- If it were feasible, would you set up your research exclusively online?
- 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*'[47]. What is your opinion on this?

[47] Haklay, M., 2013, Citizen Science and Volunteered Geographic Information – overview and typology of participation in Sui, D.Z., Elwood, S. and M.F. Goodchild (eds.), 2013. Crowdsourcing Geographic Knowledge: Volunteered Geographic Information (VGI) in Theory and Practice. Berlin: Springer. pp 105-122 DOI: 10.1007/978-94-007-4587-2_7

1.3. Crucial design factors for a citizen science project (2 hours)

The 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 considered here: (1) A communication and feedback culture, (2) Motivation strategies to participate, (3) Mechanisms for ensuring data quality, and (4) Usage of citizen science platforms for data management. This list of design factors is not exhaustive.

A communication and feedback culture
A crucial design factor in citizen science is the set-up and maintenance of a communication and feedback culture[48]. Communication is a vital aspect of citizen science, and it is a necessary part of every step of the research process. Communication activities will be needed for recruiting and engaging citizen scientists, increasing the visibility of the 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, the research (project) has 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 24hrs but 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[53]. As such, participating citizens can also become ambassadors for the research (project).
- The science communicator ensures that content is easily understandable and accessible to a broad audience. The science communicator proofreads the texts 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.

Now, what is good communication? There are many factors in place that affect the success of communication activities[49]. Overall, it is recommended that a communication plan for the research (project) is worked out. A communication plan is a detailed description of all communication steps 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. You write your communication plan in the planning phase of the research (project) and adjust it when the project is live. An important point is to set a budget. This 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).

A couple of factors are listed below that need to be considered for a successful communication strategy[50]:

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[48] Capdevila, A. S. L., Kokimova, A., Ray, S. S., Avellán, T., Kim, J., & Kirschke, S. (2020). Success factors for citizen science projects in water quality monitoring. *Science of the Total Environment*, *728*, 137843. [53] Source: https://www.futurelearn.com/courses/weobserve-the-earth

[49] Rüfenacht, S., Woods, T., Agnello, G., Gold, M., Hummer, P., Land-Zandstra, A., & Sieber, A. (2021). Communication and dissemination in citizen science. In: K. Vohland et al. (eds.), *The Science of Citizen Science*, 475. https://doi.org/10.1007/978-3-030-58278-4_24

[50] The list is distilled from: Veeckman, C., Talboom, S., Gijsel, L., Devoghel, H., Duerinckx, A. (2019). Communication in Citizen Science. A practical guide to communication and engagement in citizen science. SCIVIL, Leuven, Belgium ; Rüfenacht, S., Woods, T., Agnello, G., Gold, M., Hummer, P., Land-Zandstra, A., & Sieber, A. (2021). Communication and dissemination in citizen science. In: K. Vohland et al.

- 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 the 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, a government authority which is interested in the project for instance. 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: 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 the 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 the project, 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 the project. 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: When identifying and describing your target audience, you can also match it with the most efficient communication channels and tools. 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. 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 organizations, then you will be able to reach out to more specific profiles.
- Use of language[51]: 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? 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[52]: Citizen science is a two-way communication process between researchers, participating citizens and other stakeholders (e.g. policymakers, interest groups, etc.) involved in the research (project). When planning your 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

(eds.), *The Science of Citizen Science*, 475. (https://doi.org/10.1007/978-3-030-58278-4_24) and the online MOOC of https://www.futurelearn.com/courses/weobserve-the-earth

[51] Rüfenacht, S., Woods, T., Agnello, G., Gold, M., Hummer, P., Land-Zandstra, A., & Sieber, A. (2021). Communication and dissemination in citizen science. In: K. Vohland et al. (eds.), *The Science of Citizen Science*, 475. https://doi.org/10.1007/978-3-030-58278-4_24

[52] Source: https://www.futurelearn.com/courses/weobserve-the-earth

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.

A practical guide to communication and engagement in citizen science:
You can download the guide here. 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 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.

 Reading tips:

- 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.

✍ 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)?

Motivational strategies for participation

In addition to a communication plan, it is also effective to have an engagement plan in place[53]. Engagement stands for the active involvement of citizens in the research activities and will be defined by the chosen level of participation. Therefore, an engagement strategy will focus on the identification and monitoring of motivations which support or prevent citizen scientists from taking part in the 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.

[53] Veeckman, C., Talboom, S., Gijsel, L., Devoghel, H., Duerinckx, A. (2019). Communication in Citizen Science. A practical guide to communication and engagement in citizen science. SCIVIL, Leuven, Belgium.

Motivations to take part in citizen science research can be very diverse, but they are mostly intrinsically driven[54]. 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 a particular research topic. In citizen health science, motivation is strongly linked to a personal interest in contributing towards a treatment or cure[55].

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.

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[56]. 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, a lack of feedback about the results, and a lack of recognition.

Case study: engagement metrics of the Eye for Diabetes project

'The Eye for Diabetes' project motivated citizens through Zooniverse for training 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. The graph below displays the number of contributions made on the Zooniverse platform over time. 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 suggested 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.

 Reading tips:

- 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 the 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 the research (project), you can select the most appropriate items.
- For monitoring the participation rates in the 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 s/he 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 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.

[54] Ryan, R. M., & Deci, E. L. (2000). Intrinsic and Extrinsic Motivations: Classic Definitions and New Directions. Contemporary Educational Psychology, 25(1), 54–67. https://mmrg.pbworks.com/f/Ryan,+Deci+00.pdf

[55] Wiggins, A., & Wilbanks, J. (2019). The rise of citizen science in health and biomedical research. The American Journal of Bioethics, 19(8), 3–14. https://doi.org/10.1080/15265161.2019. 1619859.

[56] Rotman, D., Hammock, J., Preece, J., Hansen, D., Boston, C., Bowser, A., He, Y. (2014). Motivations Affecting Initial and Long-Term Participation in Citizen Science Projects in Three Countries. https:// doi.org/10.9776/14054

✍ 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 the 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?

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? 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. Policymakers do not want to run the risk of inconsistency in information acquisition and processing, and therefore rely heavily on data traceability methods. For the participating citizens, 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. An agreement should thus be sought among all stakeholders involved on the definition of (acceptable) data quality.

Figure: The balance between autonomous citizen science and rigid protocols[57].

Strictly speaking, data quality is referring to the correctness, accuracy and completeness of the data[5859]. 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)[64] 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[60].

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[57] Veeckman, C., Van Herck, B., Carpentier, M., Van Laer, J. & Sterken, M., (2021). Citizen Science Roadmap for Local Government. A hands-on manual for citizen science, by and for cities and towns. SCIVIL, Leuven, Belgium.

[58] Veeckman, C., Van Herck, B., Carpentier, M., Van Laer, J. & Sterken, M., (2021). Citizen Science Roadmap for Local Government. A hands-on manual for citizen science, by and for cities and towns. SCIVIL, Leuven, Belgium.

[59] Balázs, B., Mooney, P., Nováková, E., Bastin, L., & Arsanjani, J. J. (2021). Data quality in citizen science. In: K. Vohland et al. (eds.),*The Science of Citizen Science*, 139. https://doi.org/10.1007/978-3-030-58278-4_8

[60] Kaartinen, R., Hardwick, B., & Roslin, T. (2013). Using citizen scientists to measure an ecosystem service nationwide. *Ecology*, *94*(11), 2645-2652.

In order to ensure the data quality in the research (project), there are several mechanisms that you can set up during or after the generation of data[61][62]:

- Pre-test your data protocol: Before launching a 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, FAQs, 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 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), the scientists are verifying the data themselves. They still consider this way of working to be more efficient than when they have to make 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 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. 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 to systematically cover all seasons.

 Reading tips:

- The data charter for citizen science (available in Dutch and English) can help you with further questions on data quality.
- 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 in 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

[61] Veeckman, C., Van Herck, B., Carpentier, M., Van Laer, J. & Sterken, M., (2021). Citizen Science Roadmap for Local Government. A hands-on manual for citizen science, by and for cities and towns. SCIVIL, Leuven, Belgium.

[62] 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)

- In this article by Feitag et al. (2016), additional mechanisms and strategies are described for ensuring good data quality.

✍ Share your thoughts and opinions - Time for reflection:

- 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?

Citizen science platforms for data management

Nowadays, digital platforms offer great support for the collection, analysis and visualization of citizen science data. When you start to plan the research (project), you need to reflect on whether you need any technological support and, if so, which type of platform or tool is the best suited. The technological requirements will be greatly determined by your budget, your data protocol 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[63], e.g. are citizens able to collect data in areas that are out of service, is the technology easy to use, and how will the platform be maintained in the long run?

The success of the 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[64]. Furthermore, it can also be a motivational trigger for citizens to use and discover new technologies. However, digital technology does not always have to be the answer. 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 traffic at the Muidepoort. More information: https://stad.gent/nl/muide-meulestede-morgen

In contrast, the most advanced measurement technology involves 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. 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 that open hardware and low tech are preferred, or do-it-yourself solutions from this list.

You can also decide to make use of online platforms and applications. Citizen science platforms are web-based infrastructures with one single entrance point[65]. 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.

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[63] Liu, H. Y., Dörler, D., Heigl, F., & Grossberndt, S. (2021). Citizen science platforms. In: K. Vohland et al. (eds.), *The Science of Citizen Science*, 439. https://doi.org/10.1007/978-3-030-58278-4_22

[64] Capdevila, A. S. L., Kokimova, A., Ray, S. S., Avellán, T., Kim, J., & Kirschke, S. (2020). Success factors for citizen science projects in water quality monitoring. *Science of the Total Environment*, *728*, 137843.

[65] Liu, H. Y., Dörler, D., Heigl, F., & Grossberndt, S. (2021). Citizen science platforms. In: K. Vohland et al. (eds.), *The Science of Citizen Science*, 439. https://doi.org/10.1007/978-3-030-58278-4_22

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, blog posts, 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 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.

Tips for building your application or platform:[66]
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)
- https://public.tableau.com/app/discover/social-impact

The following citizen science platforms can be used for data collection, analysis or visualisation; they are all entry-level. Also, these platforms can be used for listing and promoting the research (project) to citizens:

- 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.
- '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 internationally.
- 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.
- Tableau Public is a free platform to explore, create, and publicly share data visualizations (or vizzes, as we affectionately call them) online. Anyone can create vizzes using our in-platform web authoring or Tableau Desktop Public Edition for free. Those with Tableau Desktop Professional Edition can also publish to Tableau Public for free. With millions of inspiring data visualizations to discover and learn from, Tableau Public makes it easy to develop your own data skills and create an online portfolio of work.
- You can also promote your project on the Eu-Citizen.Science platform.

[66] Veeckman, C., Van Herck, B., Carpentier, M., Van Laer, J. & Sterken, M., (2021). Citizen Science Roadmap for Local Government. A hands-on manual for citizen science, by and for cities and towns. SCIVIL, Leuven, Belgium.

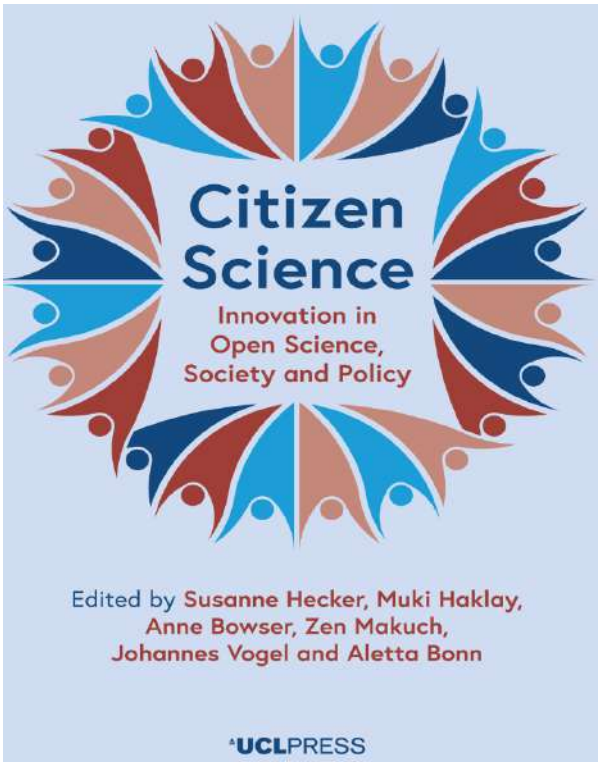
✍ Share your thoughts and opinions - Time for reflection:

- 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?

Inspire yourself and find more resources

1. EU-Citizen.Science is an online platform for sharing knowledge, tools, training and resources for citizen science – by the community, for the community. The vision for the platform is to serve as a Knowledge Hub, in aid of the mainstreaming of citizen science, and build on the growing impact of citizens participating in research across the full range of scientific enquiry.

2. The book Citizen Science: Innovation in Open Science, Society and Policy brings together some of the key insights into citizen science, exploring its potential to create new forms of knowledge generation, transfer and use and to foster the civic engagement of science. Pay particular attention to Chapter 9: Citizen engagement and collective intelligence for participatory digital social innovation, highlighting the link between digital social innovation and the basic ideas of citizen science, as well as the common challenge of motivating and structuring citizen engagement.



9

Citizen engagement and collective intelligence for participatory digital social innovation

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In: Hecker, S., Haklay, M., Bowser, A., Makuch, Z., Vogel, J. & Bonn, A. 2018. *Citizen Science: Innovation in Open Science, Society and Policy*. UCL Press, London. https://doi.org/10.14324/111.9781787352339

Highlights

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

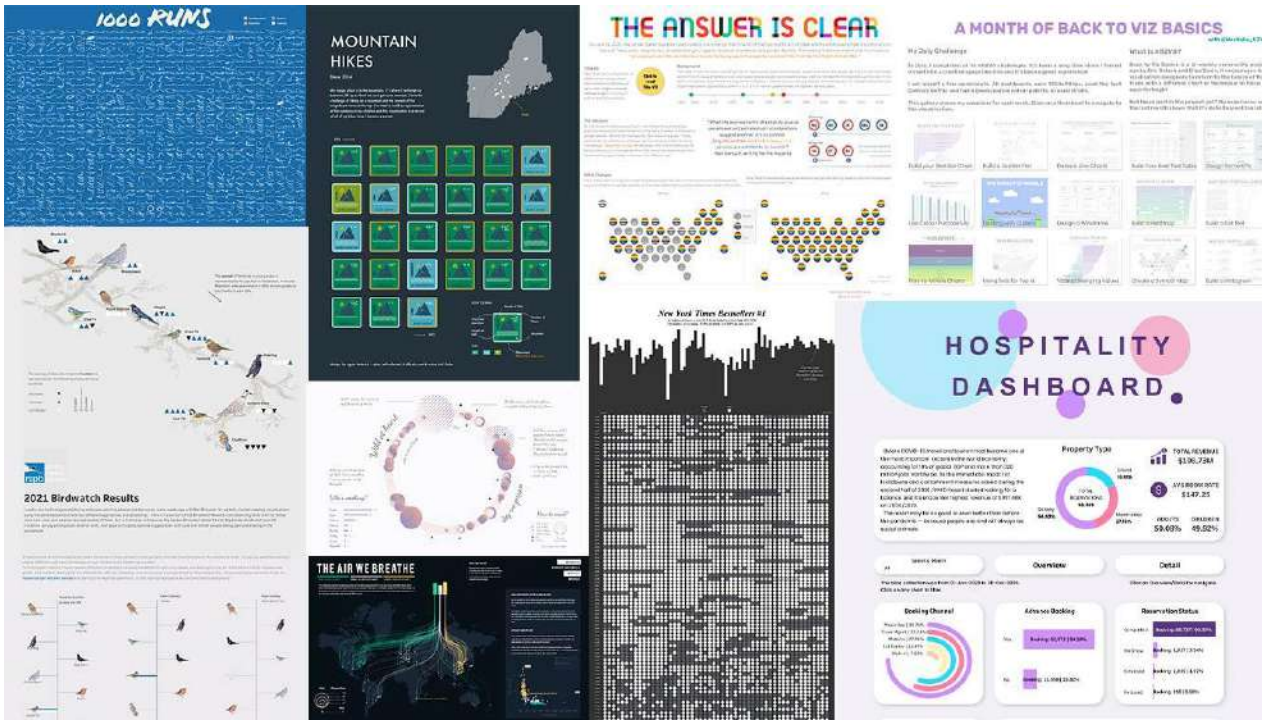
3. **OPTIONAL** video (1:19:38): Citizen Science Association (CSA) Webinar: CitSci, Community Engagement, and the UN SDGs https://www.youtube.com/watch?v=zc6ir6E17gc
Speakers discuss how citizen science can be integrated into the formal United Nations (UN) Sustainable Development Goals (SDGs) reporting mechanisms, providing the results of a systematic review of the SDG indicators and citizen science initiatives that may address them. Successful use of citizen science data by National Statistics Offices (NSOs) and UN agencies will be highlighted. Success will require leadership from the United Nations, innovation from National Statistical Offices, and focus from the citizen science community to address the indicators for which citizen science can have a real impact.

Part 2: Visualizing Data For Social Purposes with Tableau Public

Learning resources presented here are taken and adapted from https://www.tableau.com/ It is a step-by-step guide to get you started on your data viz journey.

A Beginner's Guide to Tableau Public **(2 hours)**

Tableau Public is a free platform that allows you to explore, create, and share interactive visualizations using publicly available data online. That last part is important. Make sure the data you share on Public is available for *public* consumption. Visionaries and Ambassadors publicly show off their data visualizations. This part is a step-by-step guide to help you get the most out of Tableau Public—from creating your profile all the way publishing your own data visualizations with confidence. Playing with data in Tableau Public will help you develop data skills and learn from a community of like-minded data enthusiasts—or they are also called—the DataFam. Whether it's discovering data visualizations on the topics you are passionate about (neatly categorized on the homepage) or joining one of the Tableau Community Projects, Tableau Public has the tools to help you become a data enthusiast.



Some of the data visualizations you will see featured as Viz of the Day

You can sign-up for Tableau Public by clicking this link or by navigating to the **Sign In** at the top of any page on tableaupublic.com. Once you've completed the sign-up form, you're ready to start building out your profile. Signing up for a Tableau Public account is always free and takes less than 60 seconds.

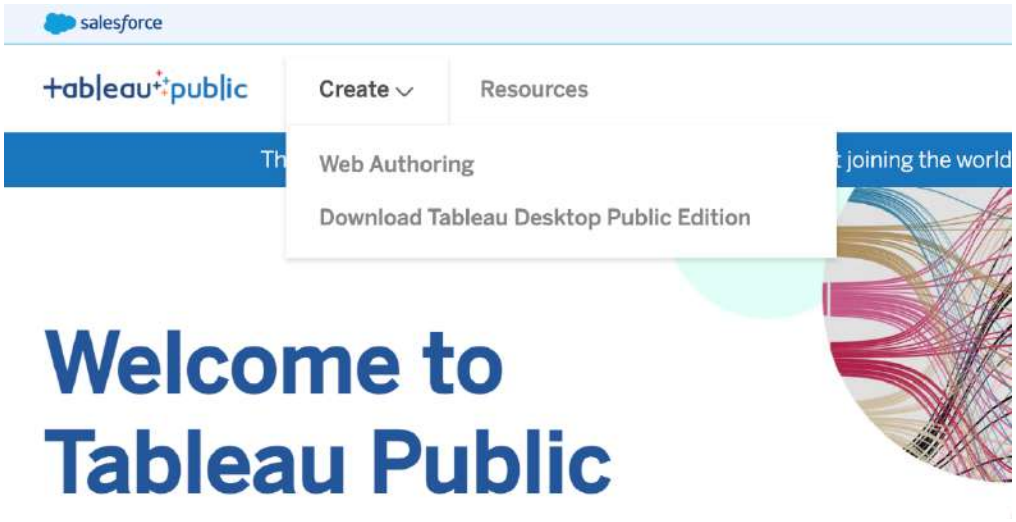
It is recommended to upload a profile photo. When considering what type of photo to upload, select a photo that you would be comfortable sharing with your professional network as you become more familiar with Tableau Public and want to show off your skills. Write a short bio note; share who you are with the Tableau Community. You can also include hashtags about your interests and/or Community Projects you're most interested in. You can add links to your social media accounts to help you connect with others in the community. You can also include links to your personal website, blog, or company website. If you choose, you can enable the Hire Me Button on your Tableau Public profile to let potential employers know you're available for work opportunities. You can enable or disable this feature at any time. Tableau Public is a global community. If so inclined, you can also add your location so that other community members can see where you are located and connect with the DataFam near you.

Once you have created the profile, it's time to build your network and explore the work of others in the community. Here are a few tips to get you started:

1. Subscribe to Viz of the Day**.** Start receiving stunning data visualizations straight to your inbox every day by subscribing to this almost-every-weekday email.
2. Explore vizzes on the Tableau Public homepage. The homepage is where you will find a collection of data visualizations across a variety of different topics including Viz of the Day, Business Dashboards, Trending, News and Events, Social Impact, and more.
3. Search the repository data visualizations to find exactly what you're looking for. With the largest repository of data visualizations in the world to learn from, Tableau Public makes developing data skills easy. Simply click the magnify glass in the upper right-hand corner of TableauPublic.com to get started.
4. Suggestion: Build relationships within the community of Visionaries and Ambassadors. Follow Featured Authors on Tableau Public**.** Every few weeks, a new group data viz rockstars from around the world is featured.

By following these steps you are now a member of the Tableau Public Community.

To publish your first data visualization here is a step-by-step guide on analyzing data and publishing a viz to your Tableau Public profile. When it comes to Tableau Public, you have two options for analyzing data and sharing your insights with others. To access them, make sure you're on a device that supports this functionality such as a laptop or desktop computer. To access Tableau Public's free data visualization tools, simply click Create in the navigation bar.



You can create data visualizations and dashboards with drag and drop ease using:

1. Tableau Public Web Authoring: Web authoring allows you to create visualizations—or vizzes—directly from a web browser. Can you create a viz without downloading any software? Yes! Since you've already set up your Tableau Public profile, all you need to do is log in and select **Web Authoring** under **Create** in the navigation bar.

2. Download Tableau Desktop Public Edition: You can also download the software directly to your Mac or PC. Select Tableau Desktop Public Edition under Create in the navigation bar on Public's website.

The basic steps for creating the first visualization are:

1. Open web authoring or the desktop app to create a viz.
2. Connect to a data source.
3. Drag and drop dimensions and measures to explore the data.
4. Once you've created one or more vizzes, you can also create a dashboard that will display multiple vizzes in a single view.
5. When you're ready to save and share your work, publish it to your Tableau Public profile.

There are several short videos on the Tableau Public website that walk you through how to get started, connect to data, navigate the workspace, create an interactive map, build a dashboard, and more. Take a look. Most of these videos are under 3 minutes long. Videos are available in 11 different languages. To select your preferred language, use the drop-down menu at the bottom of the page.

You can also find sample data sets and, if you scroll to the bottom of this page, see a list of data set sources and web data connectors. Basically, if there's a topic you're interested in learning more about, there is probably a data set available to analyze too.

Once you have watched a few tutorial videos such as **Get Started (0:22)**, **Connect to Data (2:06),** and **Navigate the Workspace Area (2:17)**, you are ready to connect to a data set and start analyzing it.

There are several resources created for the community by the community to help you learn new skills in Tableau Public. Here are a few recommended ones:

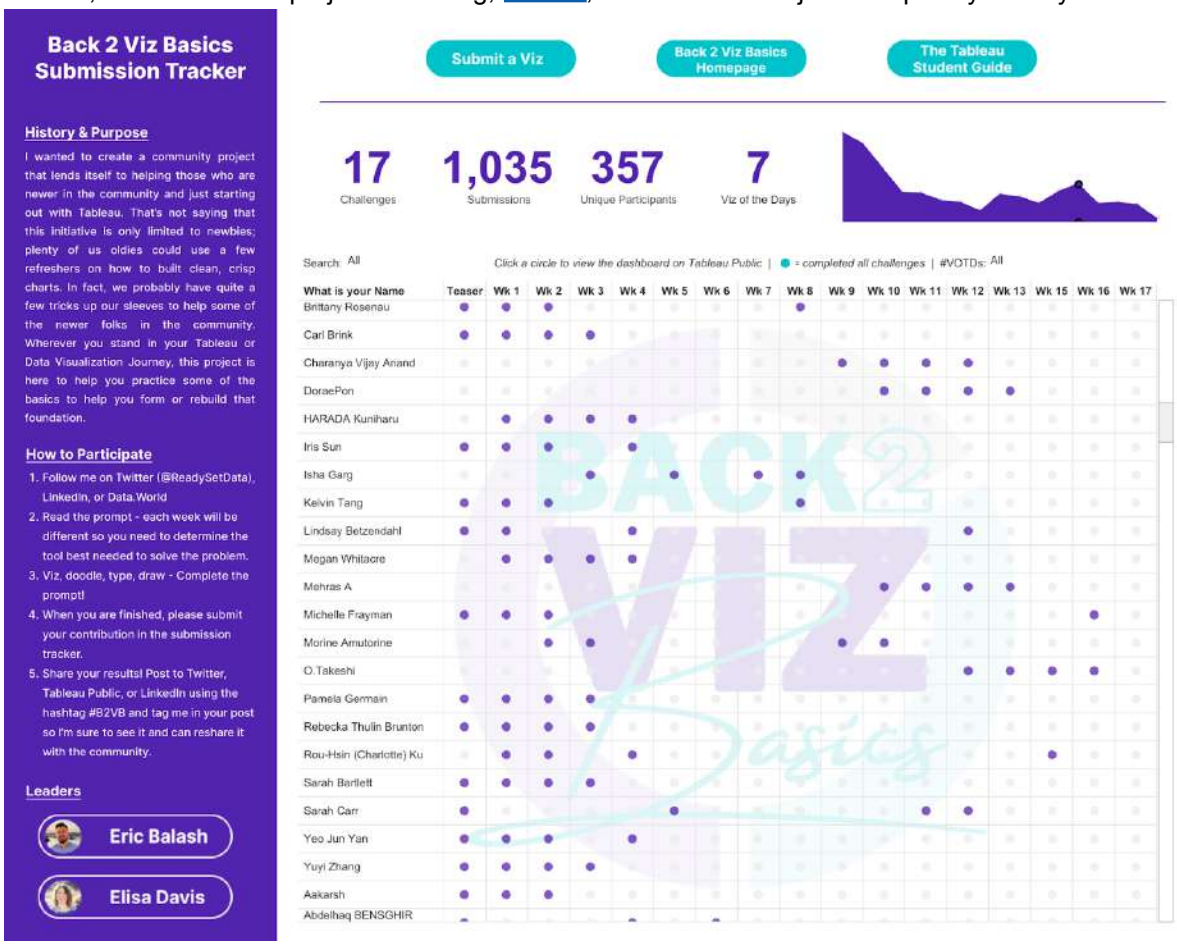
1. The Tableau Student Guide - The brainchild of former Tableau Student Ambassador Maria Brock, the Tableau Student Guide offers a number of useful resources that explore in-product features, basic chart types, projects, and more. (*Recommended for Beginners)*
2. Back 2 Viz Basics - Co-led by Tableau Public Ambassadors Eric Balsh and Elisa Davis, Back 2 Viz Basics is a Community Project that will help you build foundational knowledge using Tableau. Every other week, a new data set is published for you to practice building your own vizzes. (*Recommended for Beginner-Intermediate learners)*

See a data visualization on Tableau Public that you want to know more about? Check to see if the viz is available for download or try clicking through to the person's profile and looking to see what other information they have included on their profile page. They often will have links to LinkedIn, Twitter, personal blogs, and so forth with ways to find out more about them, their work, and even connect one-on-one.

Viz with the DataFam to Sharpen Your Data Skills delves further into Tableau Community Projects and more ways to connect with the DataFam. Tableau Community Projects are skill-based challenges designed and led by community members to help you learn, practice, and apply data skills across various topics, products, and causes. Everyone is invited to participate in these projects—at all skill levels.

Back 2 Viz Basics is a project geared towards those who are newer in the community or looking to practice Tableau and build foundational data viz skills. If you would like to explore what others have

created, search the project hashtag, #B2VB, on Public. Project frequency? Every other week.



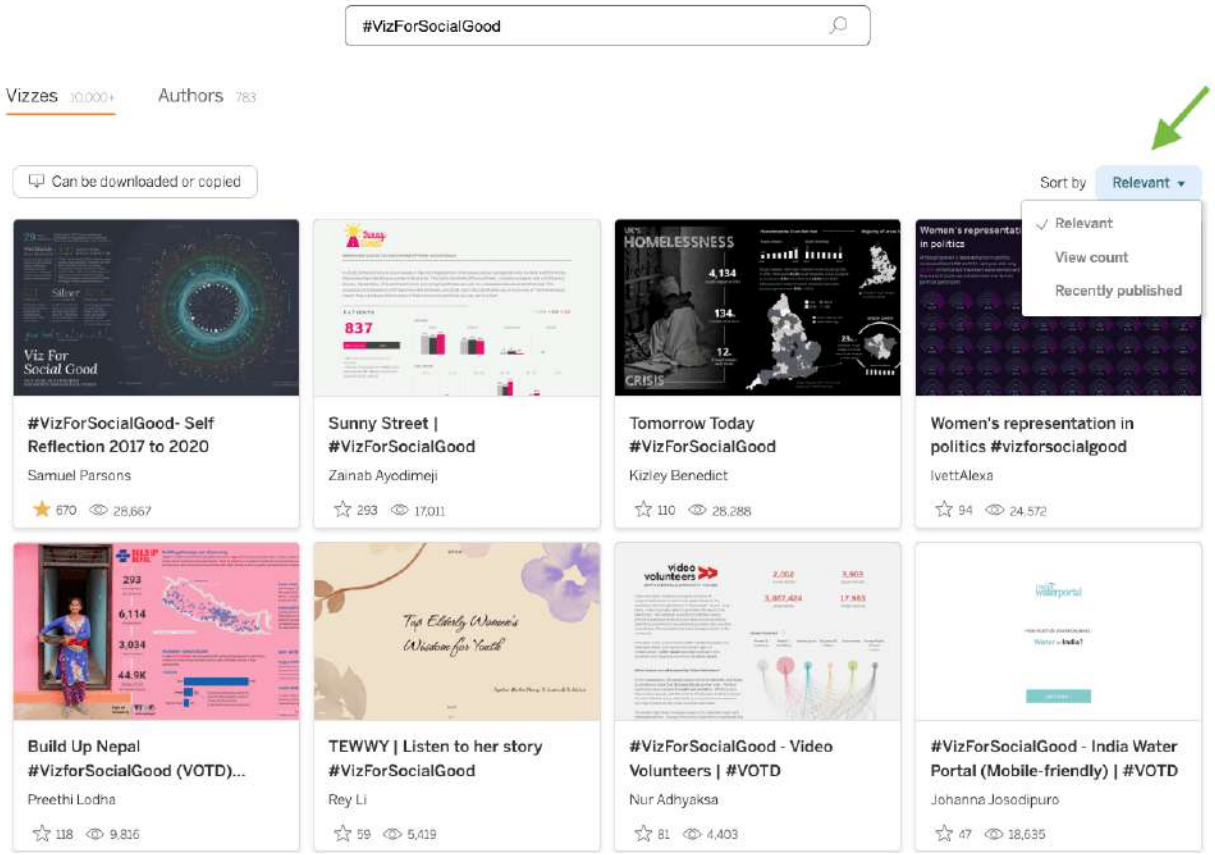
Back 2 Viz Basics Submission Tracker on Tableau Public by Eric Balash

Makeover Monday explores different perspectives and approaches to create more effective data visualizations. If you'd like to explore what others have created, search the project hashtag, #MakeoverMonday, on Public. Project frequency? Every week.

The above projects are only a few of the various community projects. Check out the complete list of community-led projects for even more options on a wide variety of topics and interests including doing good with data, healthcare-specific analysis, and so much more. On the Tableau Public homepage, you'll find many different channels to explore based on trending content, authors you follow, and topics of interest. To explore all of the vizzes in a specific collection, click See All in the upper right-hand corner of a collection. With search, you can explore your favorite topic, author, or even a specific chart type. Search results are displayed in two categories: Vizzes and Authors**.** As you're exploring keep in mind that search on Tableau Public is case sensitive so *#SportsVizSunday* and *#sportsvizsunday* will provide you with different results. For accessibility, we recommend capitalizing the first letter of each word in a hashtag whenever possible.

Channels by Topic: The are 15 different channels dedicated to topics of interest including Learning Tableau, Maps, Business Dashboards, Time Series Analysis, and so many more. Take a few minutes to browse the homepage and explore them all. Vizzes can be displayed be relevance, follower count, or recently published. You can also identify vizzes that can be downloaded or copied by using the filter in the search panel. As you're building your own vizzes and publishing them to Tableau Public, help others find

and understand them by adding a concise title, description, and appropriate hashtags in the description field.



Grading and evaluating student work (20 hours of individual work)

✍ Your assignment is to focus on a real-world problem that can be tackled by a participatory science approach.

1. Identify a specific topic, preferably from the domain of social science, where citizen-collected data can be used. It could be a topic you are interested in personally, or related to the issues you are investigating as a part of your thesis. In any case, it should be adapted to fit the provisions of the citizen science projects as described in Part 1 (section 1.1).
2. Based on the framework and series of steps provided herein, develop a citizen science project proposal. Use the ESSENTIAL ELEMENTS OF A CITIZEN SCIENCE PROJECT fact sheet as a general structure. Namely, the document that is to be submitted has to be devised following these steps and along the guidelines provided in Part 1 (sections 1.2 and 1.3):
    - Form a research question based on your idea.
    - Research and compare your project to similar citizen science projects using the criteria and typology presented in the course.
    - Determine how you want your data to be used. Use this to identify the project's scope.
    - List the stakeholders who might be interested in using your data. Propose the partners that could support you in refining your research questions and project goals.
    - Describe the diversity of the team of professionals and volunteers and include their tasks and responsibilities. Integrate a communication plan into the team responsibilities chart
    - Identify community groups that could amplify your project's impact through volunteers, communications or other forms of support.
    - Develop a project timeline.
    - Describe possible funding sources.
    - Propose the topics and mechanisms to train the volunteers to ensure a standard data collection process.
    - Describe the appropriate equipment, plans and methods for data collection.
    - Propose a plan for evaluating your project from the start.
    - Address the mechanism for analysing the volunteer-collected samples and/or results.
    - Define how you would make your data accessible so it could be used confidently and easily by others.
3. Using sample data available within the Tableau Public related to the topic of your project create a visualization. Register and follow the steps described in Part 2 Include both a screenshot and a link to the visualization in the document you will submit.

Assignment filetype: PDF, PPT, Docx

Assessment criteria:

Topic Selection (10 points)

- The chosen topic is relevant and aligns with the domain of social science.
- The topic demonstrates the potential for citizen-collected data use.
- The topic is clearly defined and articulated.

Citizen Science Project Proposal (30 points)

- The research question is formulated based on the chosen topic.
- Comparison to similar citizen science projects is conducted using appropriate criteria and typology.
- Stakeholders interested in using the data are listed, and potential partners are proposed.
- The team of professionals and volunteers is described, including their tasks and responsibilities.
- A communication plan is integrated into the team responsibilities chart.

- Community groups that can amplify the project's impact are identified.
- A comprehensive project timeline is developed.
- Possible funding sources are proposed.
- Training mechanisms for volunteers to ensure standard data collection are outlined.
- Appropriate equipment, plans, and methods for data collection are described.
- A plan for evaluating the project from the start is presented.
- Data accessibility plan is defined to ensure confident and easy utilization by others.

Visualization using Tableau Public (10 points)
- Sample data from Tableau Public related to the project topic is used.
- A visualization is created using Tableau Public following the described steps.

Overall Presentation and Organization (10 points)
- The document is well-structured and follows the provided guidelines.
- The content is presented clearly and concisely.
- The document exhibits logical flow and coherence.

Clarity and Effectiveness of Communication (10 points)
- The ideas and concepts are effectively communicated.
- The document uses appropriate language and terminology.
- The writing is clear, coherent, and free of major errors.

Total: 70 points