What is citizen science?

Citizen science is scientific research carried out wholly or partly by non-scientists (citizens), often in cooperation with or under the guidance of professional scientists.

Citizen science is a **method** for answering a **research question** in a scientific manner. All steps of the scientific process (from problem definition to communicating the results) can be elaborated with a citizen-science approach. In this sense, we prefer to speak of '**projects with a citizen-science approach**' rather than '**citizen-science projects**'.

Citizen science is therefore never a **goal** in itself: projects with a citizen-science approach have a specific goal in which the citizen-science approach is needed to achieve this goal. The goal can be part of a **social** problem that is to be mapped out in order to create awareness and/or take action, or it can be part of a **scientific** research question that is driven purely by curiosity.

There are various forms of citizen science, regarding goals, thinking and acting. These various forms each have their importance, and we want to encourage this stratification within citizen science. We therefore avoid a strict definition of citizen science, but do define preconditions to be able to speak of citizen science.

Citizen science: added value and tensions.

Citizen science can add value in three ways: 1) the generation of **new knowledge** for science or policy, 2) the creation of **awareness** of social problems in order to take action on them, and 3) the acquisition of knowledge and the development of a scientific, critical attitude among citizens (**education**). The first aspect, namely the generation of new knowledge,[1] must always be present to be able to speak of citizen science. New knowledge can be the main focus of a project, or it can play a smaller role in a project that focuses mainly on awareness and/or education.[2]

Projects with a citizen-science approach often deal with tensions in relation to

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[1] 'New knowledge' may be broadly interpreted (new data, the same data for a different geographical location, new insights, etc.). However, it always concerns knowledge that is not yet available anywhere. It is therefore not enough that citizens learn something that they did not know before, but that was already known elsewhere.

[2] Projects whose sole purpose is to inform or educate participants are engaged in science communication. Very valuable in itself, but we cannot call it citizen science.

- Ethics and privacy: both the data about the participating citizen scientists and the data they collect (consciously and unconsciously) about themselves and their environment must be sufficiently protected.

- Open data: the aim is always to make the collected data as openly available as possible (within ethical, privacy and IPR boundaries). Attention is paid to making the data findable and reusable (according to the FAIR principles) and adding informative metadata.

- Data quality: the highest-possible data quality should always be aimed for, given the goals and possibilities of the project. To ensure this, projects should rely as much as possible on a standardised scientific protocol for data collection.[3]

- Autonomy and learning of citizen scientists: participants learn most and feel most empowered when they have a high degree of autonomy in the scientific process. On the other hand, it is important for the quality of the data that it is collected according to a strict protocol, which may limit the autonomy and learning process of the participants.

Who engages in citizen science?

We propose to do away with the dichotomy between top-down citizen science and bottom-up citizen science. It is not only citizens or scientists who can initiate a project. A project with a citizen-science approach can **be initiated by** any player from the **social pentagon** (companies, authorities, knowledge institutions, financial institutions and citizens and associations) with a relevant research question. We also make a clear distinction between citizens/citizen associations who set up a project and citizens who participate in a project.

Citizen scientists[4] are people from the wider community who participate in a project with a citizen-science approach in which they perform scientific actions to answer a research question. They must be **research acts that have been informed.** By **research acts** we mean that the citizen scientists carry out activities that would be carried out by professional scientists in 'classic' scientific research. These research acts can be situated in every step of the scientific process, from formulating the research question, designing the research method, collecting or analysing data to communicating the results.

Citizen scientists carry out these research acts in an **informed** manner. This means that they are aware of the scientific protocol in which their actions are framed and the purpose of the research. We make a clear distinction between the citizen as research object and the citizen as researcher.

Projects with a citizen-science approach must focus very strongly on **communication**: to get participants excited about the project, to keep them adequately **informed**, to **train** them

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[3] Not all projects are able to collect the highest-quality data, for example because the sensors available to citizen scientists measure less accurately than expensive scientific equipment. Nevertheless, these less-accurate measurements can be a valuable addition if they are obtained in a standardised manner.

[4] We are aware of the limitations of the composite term 'citizen scientist'. 'Citizen' seems to imply wrongly that a person must be a citizen in the region where he or she wants to engage in citizen science. 'Scientist' can also be an alienating word. Many people associate science with something that is remote to them, which has little direct impact on themselves and their immediate environment and that they cannot (or should not) have much to do with.

and to **keep them constantly updated** on the progress of the project. These projects are therefore, by definition, very **open**. They aim to be accessible to all and to exclude as few people as possible on the basis of (for example) age, educational attainment, socio-economic status or financial means.

Achieving large **numbers of participants** is not in itself a good indicator of the success of a project. Some projects need a large number of citizen scientists to collect sufficient scientific data, other projects can be successful by working intensively with a very small group of citizen scientists.

Depending on the intended objectives and scale, projects with a citizen-science approach usually benefit from collaborations with **partners** from different sides of the **social pentagon**. It is not only knowledge institutions, citizens and/or civil society organisations that can initiate and support projects with a citizen-science approach, but also companies, authorities and financiers.

Recommendations and preconditions

There are also a number of recommendations to keep in mind without them being strictly necessary:

It is important to measure the impact of citizen science, both on a project level and on a wider social level. This includes not only the impact of the social/scientific issue being addressed, but also the impact on citizens (confidence in the science/policy, scientific literacy, new knowledge gained).

Projects should ideally connect and **reduce the gap between science and society** by building trust in and involvement with science.

The duration and potential value of a project with a citizen-science approach must be in line with the research question and intended impact. Not all projects should aim to be long-lasting. In some projects, a one-off collection of data is sufficient to answer the research question. When the question has been answered, the project can be closed. Other projects require a long-term operation (e.g. long-term monitoring of nature). However, in every project, short- or long-term, thought should be given from the start as to how the project can be put to optimal use and how its impact can be maximised.