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Citizen Science – Redefined

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Citizen science is not merely a game of "playing scientists" or just an educational tool; it is a way of practicing science in which we redefine who has the right to ask questions, collect data, and draw conclusions.

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A useful tool for understanding what *citizen science* (*CS*) is – and what it should be if taken seriously – is the model of four levels of engagement proposed by Muki Haklay. In this classification, projects differ primarily in the extent to which participants can influence the research process.

At the first level (crowdsourcing), participants are merely "data providers" – they perform tasks according to instructions, without any influence on research questions, methods, or interpretation of results. The second level (distributed intelligence) offers somewhat greater participation, for example through data analysis, yet still within a predetermined structure. Only at the third level (participatory science) is the idea of co-creation fully realized, because participants have an impact on the goals, methods, and use of the research results. At the fourth level (extreme citizen science), they are the initiators of the project and participate in making key decisions. The higher the level in this classification, the more citizen activity becomes a substantive social counterpart of institutional science.

Such co-created science from the higher levels of Haklay's classification – science by and for the people – should be considered a fully recognized form of research practice. Science, including academic science, is a social practice. Its rules arise from a cultural agreement: one that stipulates who is allowed to speak, what tools are employed, and in whose interest the research is conducted.

Therefore, reducing citizen science to mere crowdsourcing is not only a methodological oversimplification but also an ethical error, stripping participants of their agency and co-responsibility for the cognitive process. In international literature, first-level are, in fact, not even classified as CS.

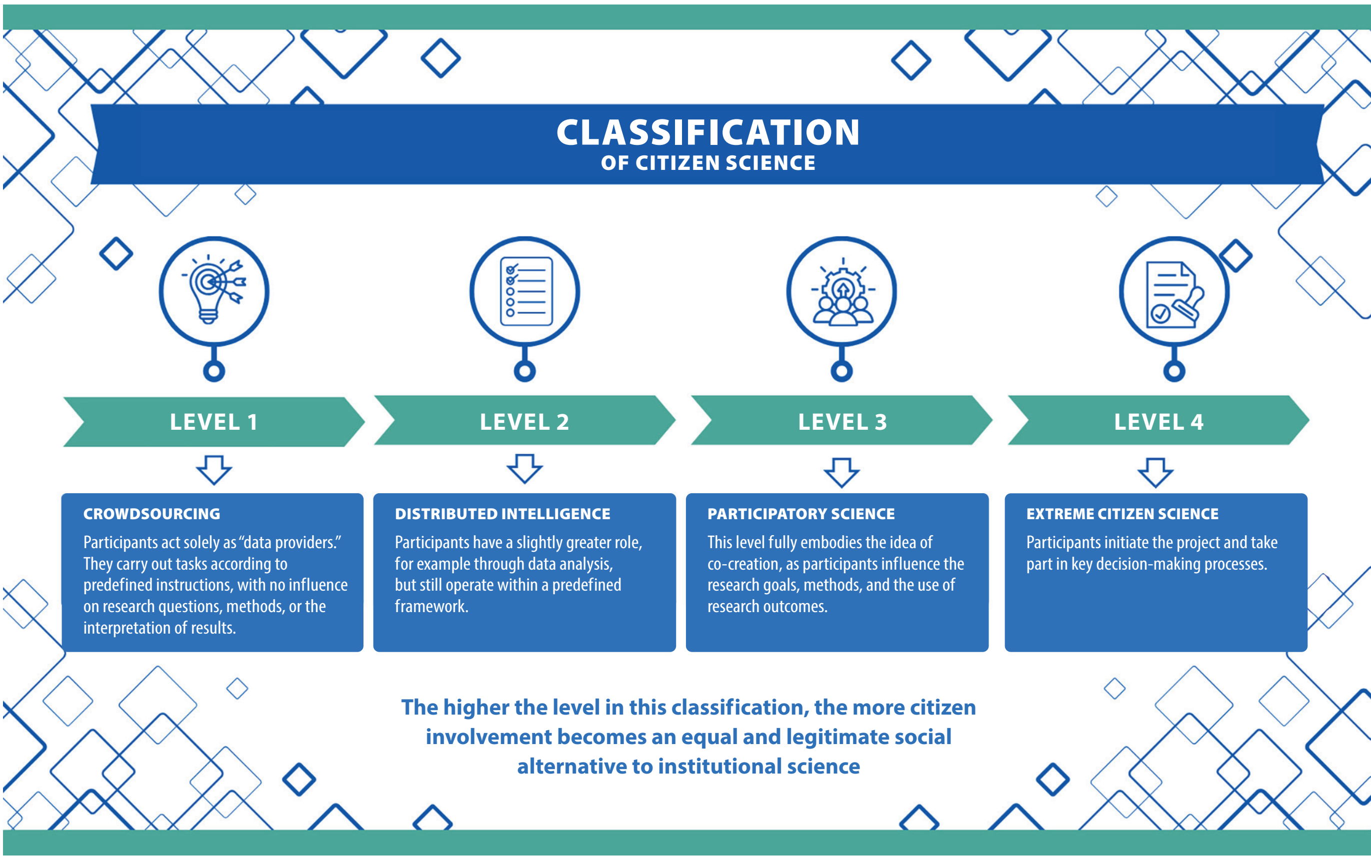
An approach offering a real partnership in action is reflected in the "10 Principles of Citizen Science" published by ECSA, according to which the participation of people outside academia is neither an exception nor a compromise, but a manifestation of the democratization of science.

Motivation: Curiosity and Impact

Why do people devote their time or personal resources to engaging in CS projects? From the perspective of the psychology of motivation, three needs play a key role: autonomy, competence and relations. Projects that allow citizens to make their own decisions (autonomy), provide clear goals and feedback (competence), foster a sense of community (relatedness), and effectively sustain participant engagement over the long term are the most successful. In practice, motivations vary depending on the field.

Persons participating in research almost always cite their curiosity about the world. The need for learning and intellectual exploration comes to the fore in astronomical projects such as Galaxy Zoo or Globe at Night (a project monitoring light pollution through observation of stars in the night sky), where participants are motivated by their fascination with outer space. Participants also value the opportunity to work with professional astronomers, to be part of global research projects, and to contribute to significant scientific discoveries.

In environmental projects, such as Naturalist or eBird, motivations often stem from concern for the



environment and the desire to protect local ecosystems and biodiversity. Participants frequently feel that their actions have a direct impact on nature conservation, reflecting the alignment of the project theme with personal beliefs and values. Many people also cite altruistic motives: they want to "help science."

Helping science also means helping oneself. In health-related projects, such as microbiome research, air-quality monitoring, or radiological protection, participants are motivated by the desire to improve their own health and that of their communities. Particularly in projects with a strong local context, a "desire to make an impact" emerges – both on one's own life and on decisions made at the local or systemic .

For example, after the Fukushima disaster, the Safecast project, a global radiation monitoring network, was launched as a bottom-up initiative, independent of governments that citizens may distrust. Similarly, as part of the CS project incubator of the RadoNorm consortium, the Citizen Observatory of Radon project was implemented in the Italian town of Abbadia San Salvatore, where participation in measuring radon levels (a radioactive gas contributing to lung cancer) in households, schools, and workplaces was combined with receiving individualized results and recommendations for reducing exposure. Participants were not merely "data providers," but also co-creators of the local public health policy.

The sense of agency becomes even more significant in initiatives where civic science is used to gather evidence on issues of substantial social importance. In places such as Cerro de Pasco in Peru, Valle de Siria in Honduras, and Carrizalillo in Mexico, the data collected by communities – with the support of Source International – documenting mining- and heavy-industry-related pollution, has contributed to court rulings, compensation payments (up to $50 million to a community for health damage), and legislative changes (due to the evidence used in the Supreme Court's ruling on the (un)constitutionality of mining regulations).

Where citizen science projects are embedded in local needs and their results lead to tangible actions, the sense of influence becomes not only a motivation but also a source of social empowerment. Science is a tool for empowerment and for fostering a sense of agency.

A separate category of projects consists of those implemented mainly online, where the key factor of engagement is the satisfaction derived from taking action independently. In both Galaxy Zoo and Foldit (in which participants compete in assembling protein structures), gamification elements were introduced through badge systems and rankings that motivated participants to continue working. At the same time, the creators ensured that participants could see the real effects of their work – for example, by informing them which protein structures had contributed to real scientific research, such as the design of new drugs.

The iNaturalist biodiversity documentation platform, where users share photos of plants and animals, has focused on fostering a strong community and interaction between users – they can jointly identify observed species, comment, and learn from one another. Similarly, eBird, a global bird monitoring project in which participants from around the world record their observations, has built a large international community by offering users tools to record their own observations, create species lists, and compare results with others. Regular events, such as Global Big Day, motivate participants to be actively involved and foster a sense of community.

How, then, can we encourage and maintain participant engagement in such projects? Study results suggest the following guidelines:

1. **Design participation pathways** with gradually increasing s of effort, from micro-tasks to co-design, so that participants can choose a role that matches their competence andcapacity.
2. **Ensure inclusive internal communication** – not only one-way updates about results but also dedicated time for discussion – to strengthen participants' sense of inclusion in the project.
3. **Remove accessibility barriers** (ensuring and maintaining mobility, equipment and access to it, language skills, and time) to actively increase the diversity of people participating in the project.

As Credible as Scientists

A question emerges: is the data collected by amateurs reliable? I will answer it rather bluntly: is the data collected by scientists inherently reliable? Credibility does not stem from the academic title of the person collecting the sample, but from following protocols, implementing quality control, and performing validation.

Many publications emphasize that the source of errors in CS projects is not the participants, but rather the lack of appropriate methodology and support from experts. In well-designed citizen science projects, such mechanisms are standard. In Galaxy Zoo, each image is independently evaluated by a dozen (!) or more people, and the final result is determined through statistical analysis of the responses, with the algorithm taking into account the "credibility" of each user. In RadoNorm projects, it was experts who were responsible for ensuring that the instruments used in the project were calibrated, in addition to holding a calibration certificate from an accredited laboratory. Additionally, during participant training, the importance of these procedures was emphasized. In many projects using simpler environmental sensors, participants' data are regularly compared with results from institutional reference stations.

Depending on the type of project, specific solutions may vary, but the common factor is the large amount of data collected – often far exceeding what could be gathered by a single research team. It is precisely this substantial quantity that allows potential inaccuracies of individual observations to be compensated for. Since the data collected in citizen science projects can sometimes be heterogeneous, incomplete, or obtained from different sources and with varying levels of accuracy, the Bayesian approach is particularly useful for analysis. It allows the full potential of a large number of dispersed measurements to be utilized, even if individual observations are burdened with greater uncertainty. In this way, quantity becomes quality.

Where to Look for Inspiration?

If the above arguments have inspired someone to join or organize citizen science projects, but the pressing question of "How do I get started?" remains, the following resources can be helpful.

On the SciStarter (scistarter.org) and the European Citizen Science Association (ECSA) (www.ecsa.ngo) websites, you can find project repositories, including those open for participation. The website dedicated to the European Union Prize for Citizen Science Projects, a competition organized by Ars Electronica in cooperation with the European Commission, features videos about prize-winning projects (ars.electronica.art/citizenscience/en). The awards themselves are funded by the Impetus project – an EU program under Horizon Europe, carried out from 2022 to 2026 by a consortium of seven partners from four countries. Information about open calls can be found on the project website (impetus4cs.eu).

Since citizen science projects in Poland are dispersed, together with Prof. Aleksandra Ziembińska-Buczyńska from the Science Popularization Center at the Silesian University of Technology in Gliwice, we have taken steps to network people working with this methodology in Poland. We are pleased that the inaugural networking meeting, organized by the Science Popularization Center (CPN) in June 2025, attracted several dozen participants. We encourage everyone interested in joining this network to fill out the form (QR code) available on the Science Popularization Center's website at the Silesian University of Technology. ■

Further reading:

Cooper C., *Citizen Science: How Ordinary People Are Changing the Face of Discovery*, New York 2016.

European Citizen Science Association (ECSA), *10 Principles of Citizen Science*, ecsa.citizen-science.net

Haklay M., *Citizen Science and Policy: A European Perspective*, Washington 2015, www.wilsoncenter.org/sites/default/files/media/documents/publication/Citizen_Science_Policy_European_Perspective_Haklay.pdf

Impetus for Citizen Science (Horizon Europe project), impetus4cs.eu

Pateman R., Dyke A., West S. *The diversity of participants in environmental citizen science*, „Citizen Science: Theory and Practice" 2021, DOI: 10.5334/cstp.369

TEN PRINCIPLES OF CITIZEN SCIENCE

Citizen science is a flexible concept which can be adapted and applied within diverse situations and disciplines. The statements below were developed by the '*Sharing best practice and building capacity*' working group of the **European Citizen Science Association**, led by the Natural History Museum London with input from many members of the Association, to set out some of the key principles which as a community we believe underlie good practice in citizen science.

1. **Citizen science projects actively involve citizens in scientific endeavour that generates new knowledge or understanding. Citizens may act as contributors, collaborators, or as project leader and have a meaningful role in the project.**
2. **Citizen science projects have a genuine science outcome.** For example, answering a research question or informing conservation action, management decisions or environmental policy.
3. **Both the professional scientists and the citizen scientists benefit from taking part.** Benefits may include the publication of research outputs, learning opportunities, personal enjoyment, social benefits, satisfaction through contributing to scientific evidence e.g. to address local, national and international issues, and through that, the potential to influence policy.
4. **Citizen scientists may, if they wish, participate in multiple stages of the scientific process.** This may include developing the research question, designing the method, gathering and analysing data, and communicating the results.
5. **Citizen scientists receive feedback from the project.** For example, how their data are being used and what the research, policy or societal outcomes are.
6. **Citizen science is considered a research approach like any other, with limitations and biases that should be considered and controlled for.** However unlike traditional research approaches, citizen science provides opportunity for greater public engagement and democratisation of science.
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.**

September 2015, London