PROCEEDINGS OF SCIENCE

The Activities & Dimensions Grid of Citizen Science

Michael Strähle[a,*] **and Christine Urban**[b,*]

[a] *Wissenschaftsladen Wien – Science Shop Vienna,*
Währinger Straße 59, 1090 Vienna, Austria
https://orcid.org/0000-0002-4011-2619

[b] *Wissenschaftsladen Wien – Science Shop Vienna,*
Währinger Straße 59, 1090 Vienna, Austria

E-mails: ms@wilawien.ac.at, cu@wilawien.ac.at

There are now at least as many typologies and categorisations of citizen science as there are ideas and explanations of what citizen science is. What counts as citizen science is not a foregone conclusion. In the Horizon 2020 project CS Track, the authors systematically examined different approaches to categorising citizen science activities and created a grid of citizen science activities and their dimensions, the Activities & Dimensions Grid of Citizen Science. The Grid is based on the European Commission's broad concept of citizen science. More detailed and systematic than previous categorisations, it shows the complexity and contexts of citizen science, namely what can be citizen science and on which dimensions citizen science activities depend, such as the location of participation, the requirements for participating in a citizen science activity, demographic aspects of who is participating, funding schemes and others. The systematic consideration, the result of which is The Grid, allows a better view of possible pitfalls and ethical questions, as well as questions of inclusion and exclusion in citizen science. Some of these issues only become visible through this systematic analysis, others only become sufficiently specific and thus accessible for an answer. This paper presents the above-mentioned grid, how the different categorisations of citizen science were incorporated, and how The Grid can be used for citizen science activities to identify possible pitfalls, ethical aspects, and aspects of inclusion and exclusion of the respective citizen science activities.

Engaging Citizen Science Conference 2022 (CitSci2022)
25-26 April 2022
Aarhus University, Denmark

[*] Authors listed alphabetically

PoS(CitSci2022)087

1. Introduction

Citizen science is a fuzzy concept. There are several definitions and explanations of citizen science (e.g., [2], [4], [6], [7], [9]) which overlap. Some of these definitions are quite broad because they include science communication activities or public participation in science policy (e.g., [6]), while some restrict citizen science to engaging laypersons in scientific research purposes (e.g.,[4]). "Citizen science" has become an umbrella term for quite different practices.

There is no undisputed definition of the term. In fact, whether a definition is useful, or even necessary, has been discussed [1], [12]. In view of the broad application of the term, researchers have developed various categorisations and typologies of citizen science activities to provide an overview of the various forms citizen science can take [2], [3], [5], [8], [10], [11], [14], [15], [16], [17], [18], [20], [21], [22]. (For an analysis of some of these categorisations and typologies, see Strähle and Urban [19], chapter 6.) Generally, definitions, categorisations and typologies are made for a specific purpose. Among other things, CS Track investigates the benefits of citizen science, the incentives, disincentives and enablers for citizen science, and the barriers to citizen science. The authors developed the Activities & Dimensions Grid (see Strähle and Urban [19], p. 100-105) to provide, on the one hand, an overview of potential citizen science activities and their dimensions tailored to CS Track and, on the other, a conceptual framework for research activities in the CS Track project dependent on them. The Grid can be operationalized in the ideal event that all information about the dimensions of a specific citizen science activity is available. Research expected to utilise The Grid includes qualitative and quantitative social research on citizen science projects and web analytics of the marks their activities leave in social media.

2. Methodology

Categorizations, typologies or classifications are always based on certain understandings of what is or is not citizen science. Because CS Track is a research project funded under the European Commission's Horizon 2020 Framework Programme, the definition or explanation of citizen science underlying The Grid is from the Science with and for Society Work Programme 2018 - 2020:

"(...) citizen science should be understood broadly, covering a range of different levels of participation, from raising public knowledge of science, encouraging citizens to participate in the scientific process by observing, gathering and processing data, right up to setting scientific agenda and co-designing and implementing science-related policies. It could also involve publication of results and teaching science." (European Commission [5], p. 41)

For compiling The Grid, the authors examined frequently discussed categorisations, typologies and conceptualisations of citizen science and analysed them with respect to their applicability for CS Track's research objectives and methodologies. In a next step, the Activities & Dimensions Grid of Citizen Science was reviewed against additional categorisations and meta-analyses of such categorisations and refined [2], [3], [5], [8], [10], [11], [14], [15], [16], [17], [18], [20], [21], [22]. The analyses were complemented by examinations of aspects that needed additional evaluation. The guiding questions of the analyses were: What activities are considered as citizen science? What categories, dimensions,

types and characteristics of activities were taken into account? Which activities are useful for empirical research in CS Track and beyond?

3. Structure of The Grid

The authors came to the conclusion that activities rather than projects are the units to be regarded as objects of analysis. A project can include several different activities that have to be examined one by one. The various activities and the circumstances under which they take place raise different issues with respect to potential benefits and caveats, barriers and enablers, incentives and disincentives. Combining all characteristics of citizen science activities considered as possible would easily result in hundreds or thousands of categories, depending on the granularity of the operationalisation of the characteristics. Hence, it made more sense to compile a grid that gives an overview of how citizen science activities can be differentiated by dimensions.

The Grid is based on *four distinguished areas of citizen science activities*:

- Area 1: Providing input for research policy
- Area 2: Taking part in scientific research
- Area 3: Taking part in development & innovation
- Area 4: Citizen science in school education

Depending on circumstances, the respective activities can be different in nature and impact; and their potential benefits and caveats, barriers and enablers, and incentives and disincentives for them depend on the contexts they are part of. To mirror differences in context and circumstances, it was decided to assign different dimensions to each activity.

Area 1 is about involving "the public" or "citizens" in science policy. Activities in this area include citizen consultations and deliberative formats such as citizen juries for agenda setting and similar topics. Caveats, enablers and barriers here are principally the same as the ones for formats of deliberative formats. The most important issues are about the democratic and egalitarian aspects of all steps, i.e., procedures to decide on topics, information procedures, documentation, etc., and, most of all, how to give citizens involved equal opportunities to be selected as participants.

Area 2 is probably the largest category of citizen science activities. In this area volunteers participate in the scientific process in auxiliary activities by taking samples and making observations, for instance. However, activities can also include deciphering handwritings, setting up libraries, and formulating research questions. Research objectives are most important here.

Area 3 concerns the engagement of citizens with development and innovation activities. This can include usability testing, user acceptance testing, and assembling open hardware sensors for measuring air quality, for instance. Activities in this area also include DIY R&D in biology and in FabLabs citizens conduct on their own behalf.

Area 4 is about CS in school education. Principally, most activities from the first three areas can be realized with pupils. The school context has a huge impact on how potential benefits and caveats of ethical issues have to be evaluated. For one, schools provide the human right to best possible education for each child. Hence, the objective of educating children is—or should be —the absolute priority of the citizen science activity, while research is

a side benefit. School is obligatory for minors and even in after-class activities one cannot regard pupils as strictly volunteers: There can be some informal pressure to participate. Children cannot walk away from school like adults in a university course could. And when citizen science becomes a didactic tool, one has to ask how it compares to other didactic tools and if all children benefit equally from it, especially those who come from families which have received less education than average.

In The Grid the following *dimensions of citizen science activities* are identified:

- location of participation
- requirements for participation
- scale of the project
- characteristics of the country where an activity takes place
- geographic coverage of an activity
- beings/objects dealt with
- funding
- initiators of an activity
- organisers of an activity
- whom citizen scientists are known to
- partners as citizen scientists
- individuals as citizen scientists
- individuals as "traditional" scientists
- topic areas and/or disciplines
- promised incentives and remunerations

Some categorisations use objectives of citizen science projects as a criterion for distinguishing between different forms of citizen science. Having reflected on this, the authors of this paper decided against using the objectives of a citizen science activity as a dimension. One reason for declining to distinguish between forms of citizen science by their objectives is that not everyone engaging in a citizen science activity necessarily has the same idea of its objectives. Additionally, objectives can change over time. Also, we often find a bundle of objectives that are intertwined. It is not always clear which objectives have priority for whom. Most importantly it is questionable how much practical impact the (initial) objectives (of different actors) have for an assessment of a citizen science activity in terms of potential benefits, caveats, barriers, enablers and (dis-) incentives. For example, research objectives and education are two often named main objectives. In university education they are often too intertwined to be clearly separated. But even if only one is named explicitly as an objective, some minimum standards for the other objective would remain desirable in terms of potential benefits and caveats. A citizen science activity that claims to be mostly educative would not be deemed as beneficial if it is questionable research. If a citizen science activity explicitly aims at research only, and not at education, learning cannot be fully avoided if people engage in something new. Hence, all information given to them must be accurate and meet usual scientific standards. Otherwise, there would be a trade-off between the declared objectives and the undesired side-effects of the activity. While the planned objectives of an activity matter less than its results when it comes to evaluating citizen science activities, the open declaration of objectives by those who organize a citizen science activity could be evaluated as a part of its transparency.

4. Discussion

What the barriers enablers, incentives, disincentives, and potential benefits of a specific citizen science activity is something that can only be determined by providing as complete a picture of the dimensions of the activity as possible. Two activities may look very similar at first sight but when their dimensions are considered they may look very different, which can raise different concerns as well as influence expectations.

For example, a high number of working hours of volunteers can be an asset in one citizen science activity, if these working hours are performed by resourceful individuals in their leisure time. The same workload, however, would raise ethical concerns if pupils are the ones contributing to the project and their education in basic skills is being impacted. It would still have to be judged differently if the participants are adults with low resources with respect to time or finances and/or one could not be sure that there is no structural pressure being placed on them to participate in the activity. On the other hand, if the participants are volunteers, who do not have to economise on their resources, this can be an issue too if they could disproportionately benefit from the outcomes of an activity at the expense of others with less resources, for instance, in cases where they might influence a research agenda to their advantage. Are citizen science activities that can be carried out by anyone comparable with those that require special skills or long-lasting experience, for example, in dealing with rare archaeological artifacts or endangered species? Should an activity involving the processing of private data be evaluated in the same way as one in which participants remain anonymous and no private data are collected? Obviously, different aspects have to be taken into account when investigating the benefits, caveats, enablers, barriers and (dis-)incentives of citizen science activities. This is one of the reasons why a categorisation of activities that would consider even some of the most obvious dimensions would result in a very high and unmanageable number of categories. The solution to this was to compile The Grid, because only a grid can reflect as many dimensions as possible.

Altogether, The Grid includes almost all citizen science activities and dimensions other scholars mention, but in a more detailed form that makes manifestations of such activities and dimensions measurable. Operationalised, such a differentiation allows for targeted evaluations of citizen science activities and for drafting context-sensitive guidelines and recommendations. Closer attention to the contexts of and differences between activities is a first step towards a better understanding of actual and potential ethical issues.

Acknowledgments

Research for this paper has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 872522.

The authors thank all the anonymous reviewers of this paper for their comments and Reviewer #1 for pointing to two classifications of citizen science activities based on degree of digitisation or AI support ([3], [15]) that have not been taken into account in the original version of this paper. The Grid was reviewed against them and an explanatory footnote was added to it (see Table 1).

References

[1] JAuerbach et al., The problem with delineating narrow criteria for citizen science, *Proceedings of the National Academy of Sciences* **116** (2019). https://doi.org/10.1073/pnas.1909278116

[2] R. Bonney et al., Public participation in scientific research: Defining the field and assessing its potential for informal science education. A CAISE inquiry report (2009). https://eric.ed.gov/?id=ED519688

[3] L. Ceccaroni et al., Opportunities and Risks for Citizen Science in the Age ofArtificial Intelligence, *Citizen Science: Theory and Practice* **4** (2019). https://doi.org/10.5334/cstp.241

[4] Citizen science, *Oxford English Dictionary*, https://www.oed.com

[5] C. Cooper et al., Project Categories to Guide Institutional Oversight of Responsible Conduct of Scientists Leading Citizen Science in the United States, *Citizen Science: Theory and Practice* **4** (2019). https://doi.org/10.5334/cstp.202

[6] European Commission, Horizon 2020: Work Programme 2018–2020: 16. Science with and for Society (2018). https://ec.europa.eu/research/participants/data/ref/h2020/wp/2018-2020/main/h2020-wp1820-swfs_en.pdf

[7] European University Association, EUA OpenScience Survey 2020-2021. http://www.eua.eu

[8] C. Franzoni and H. Sauermann, Crowd science: The organization of scientific research in open collaborative projects, *Research Policy* **43** (2014). https://doi.org/10.1016/j.respol.2013.07.005

[9] Green paper on Citizen Science for Europe: Towards a society of empowered citizens and enhanced research (2013). https://digital-strategy.ec.europa.eu/en/library/green-paper-citizen-science-europe-towards-society-empowered-citizens-and-enhanced-research

[10] M. Haklay, Citizen Science and Volunteered Geographic Information: Overview and Typology of Participation, in *Crowdsourcing Geographic Knowledge*, ed. D. Sui et al., Springer, Dordrecht (2013). https://doi.org/10.1007/978-94-007-4587-2_7

[11] M. Haklay, How many citizen scientists in the world? Po Ve Sham – Muki Haklay's Personal Blog (2018). https://povesham.wordpress.com/2018/10/05/how-many-citizen-scientists-in-the-world/

[12] F. Heigl et al., Toward an international definition of citizen science. *Proceedings of the National Academy of Sciences* **116** (2019). https://doi.org/10.1073/pnas.1903393116

[13] M. J. Pocock, J. C. Tweddle, J. Savage, L. D. Robinson and H. E. Roy, The diversity and evolution of ecological and environmental citizen science, *PLoS One* **12** (2017). https://doi.org/10.1371/journal.pone.0172579

[14] B. Prainsack, Understanding participation: The 'citizen science'ofgenetics, in *Genetics as social practice*, ed. B. Prainsack et al., Farnham:Ashgate (2014). https://doi.org/10.4324/9781315584300

[15] J. Rafner et al., Revisiting Citizen Science Through the Lens of Hybrid Intelligence, https://arxiv.org/abs/2104.14961v1 (2021)

[16] P. Schrögel and A. Kolleck, The Many Faces of Participation in Science: Literature Review and Proposal for a Three-Dimensional Framework, *Science & Technology Studies* **32** (2019). https://doi.org/10.23987/sts.59519

[17] F. Serrano Sanz et al., White Paper on Citizen Science in Europe (2014). http://www.zsi.at/object/project/2340/attach/White_Paper-Final-Print.pdf

[18] J. L. Shirk et al., Public Participation in Scientific Research: A Framework for Deliberate Design, *Ecology and Society* **17** (2012). https://doi.org/10.5751/es-04705-170229

[19] M. Strähle and C. Urban, Framework Conceptual Model (2021). https://doi.org/10.5281/zenodo.5589618

[20] A. Wiggins and K. Crowston, From conservation to crowdsourcing: A typology of citizen science, *Proceedings of the 44th Annual Hawaii International Conference on System Sciences* (2011). https://doi.org/10.1109/HICSS.2011.207

[21] A. Wiggins and K. Crowston, Goals and tasks: Two typologies of citizen science projects, *45th Hawaii International Conference on System Sciences* (2012), https://doi.org/10.1109/HICSS.2012.295

[22] A. Wiggins and K. Crowston, Surveying the citizen science landscape, *First Monday* **20** (2015). https://doi.org/10.5210/fm.v20i1.5520