Inclusion and exclusion in citizen science: A matter of context

Michael Strähle[1], Christine Urban[1]

[1] Wissenschaftsladen Wien – Science Shop Vienna

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Abstract. Associated with promises of inclusion and sometimes the democratisation of research processes, citizen science is a highly normatively charged term. These promises often go hand in hand with the optimistic claim that citizen science is per se anti-elitist and anti-traditionalist and stands for openness, civic education – and indeed inclusion. Inclusion is a frequent topic of critical discussions among those who publish on citizen science. This paper argues that for several reasons these promises are far from being self-evident. First of all, citizen science is not a clear-cut, well-defined concept. Secondly, it is also not clear what inclusion in citizen science activities means if it is discussed on a too general level. Which forms of inclusion and exclusion citizen science can produce depends on the respective citizen science activities and their dimensions, i. e. conditions these activities depend on. These forms have to be known to assess if an activity should be inclusive. For their Activities & Dimensions Grid of Citizen Science, which is based on a very broad description of citizen science by European Commission, the authors roughly grouped citizen science activities into four areas: citizen science in 1) science policy, 2) scientific research, 3) development and innovation, and 4) school education. In this paper the authors describe for each area exemplarily, how inclusion and exclusion may happen. Furthermore, they argue that inclusion is not an end in itself and not an important aspect of every citizen science activity.

1 Citizen science – not a clear-cut concept

"Inclusion in citizen science" - this immediately raises several questions: what is citizen science? What is meant by inclusion? And finally, what is inclusion in citizen science? Let us start with citizen science. Originally, Alan Irwin (1995), in his book with the same title, used this term to describe a form of science that takes societal concerns seriously and addresses them in a democratic exchange with citizens. At about the same time, the Cornell Ornithology Lab coined the term “citizen science” as a kind of participatory science. Significantly later than Irwin and the Cornell Ornithology Lab began to use it, the term “citizen science” has gained prominence as a search term since at least 2015, according to a Google trend analysis, and it is reasonable to assume that this term is beginning to outrank, if not successively replace, the term "public engagement in science", a Google trend analysis suggests. It is not always clear what citizen science

is. There are dictionary definitions of the term, according to which citizen science is characterised by the fact that volunteers participate in research projects, for example by announcing plant or animal observations (e.g., OED, n. d.; Lexico, n. d.). For others, this concept of citizen science is not broad enough. For them, it also includes the formulation of research questions, participation in research policy decisions, projects of a research nature in schools or even amateur science. The description of citizen science published by the European Commission in the work programme Science with and for Society (European Commission, 2018) includes all of them: the scientific auxiliary activities of volunteers, the co-design of research projects by citizens, so-called amateur science, science education in schools, science communication in the sense of outreach activities and the participation of citizens in research policy.

2 Inclusion as a topic of discussion in citizen science communities

In a nutshell, there is no definition or explanation of citizen science on which those involved in citizen science can agree unanimously; indeed, they do not even agree on whether such a definition or explanation is necessary. Which brings us to the middle of debates about the inclusivity of citizen science. While Heigl et al. (2017 & 2019) argue that a common understanding of what constitutes citizen science is necessary for the acceptance of citizen science in scientific communities, Auerbach et al. (2017) argue against it because they fear that a definition of citizen science might exclude some forms of citizen participation in research processes from being considered citizen science. According to them, to remain as inclusive as possible, there should be no binding definition of citizen science. In citizen science communities there are also debates about the inclusivity of citizen science via terminology debates, in which the term "citizen" is primarily problematised (e.g., Eitzel et al., 2017). Who is addressed by "citizen"? How should participants in citizen science activities be referred to in an appreciative way? Are "layperson" and "volunteer" derogatory terms? These are questions that are being asked and discussed in detail. However, in all these debates there is no discussion about whether the term "science" is the right one at all, as if there were no questions about what is meant by it. The question is who is engaging in these debates. Apparently, these debates are mainly led by scientists. In her study, Tancoigne (2019) has found that on Twitter organisers of citizen science activities and media reporting about them persistently used the terms "citizen science" and "citizen scientist" as a brand name, so to speak, but many of the other participants did not. It would require additional research to find out why that is so. (For a detailed discussion of these terminology debates, see Strähle & Urban (2021)).

Inclusion is at the core of the whole concept of citizen science, which defines itself by including people into research, who are usually not involved in it. The difficulty is to define an activity according to who is performing it. In the case of citizen science, “science” becomes “citizen science”, if done by non-professionals or if they contribute

to it. But does science depend on who carries it out, or rather on what is done and how, if and what scientific protocols are applied, if the applied used methods are sound, the analysis is comprehensible, etc.? From a normative point of view, if a non-professional or an autodidact meets scientific standards, it is science. Conversely, formally trained scientists do not always perform sound research.

3 Promises of citizen science

Irrespective of all conceptual confusions surrounding citizen science, on its way up the totem pole of science policy it was supported by more or less unsubstantiated, but nevertheless strong promises what it can achieve. Strasser et al. (2019) group these promises into three themes: a greater democratisation of science, better scientific literacy, and new scientific breakthroughs" (p. 62). Kimura & Kinchy (2016) think that these promises create expectations that sometimes conflict with each other. Basically, it is largely unclear which promises of inclusion and democratic participation citizen science can keep. Since despite its increasing popularity, there has been little systematic research on who participates or wants to participate in citizen science projects (e.g., See, 2016; Pandya & Dibner, 2018; Füchslin et al., 2019; Burgess et al., 2017), however, according to Pandya & Dibner (2018), Haklay (2013), Füchslin et al. (2019) and Strasser et al. (2019) cumulative effects in favour of middle-class individuals are also likely to be evident in citizen science. Seen in this light, it is difficult to answer the question of how inclusive citizen science is. How, then, can we generally verify the promises of some proponents of citizen science with regard to inclusion and participation? Some of the reasons why citizen science cannot keep all its promises are conflicting expectations of and insufficient knowledge about who actually participates in citizen science activities and who benefits from these activities on the one hand, and on the other that the promises are quite general.

4 What could inclusion mean in citizen science?

As it is far from being clear what citizen science is, the question remains: what is inclusion? Generally speaking, aiming at inclusion in citizen science activities means that everyone who is interested in participating has the same chance to do so as all others who are interested. The participation of a broad range of people or socio-economic diversity of participants, even if there is empirical evidence for it, does not proof that an activity is specifically inclusive, although the opposite may be an indicator of non-inclusiveness. If participants in an activity are a relatively homogeneous social group, very often this can be taken as a proof that an activity is not inclusive, albeit with some exemptions, e. g. activities that are of interest only to representatives of a certain profession, who share also some socio-economic characteristics. The fact that homogeneity can be a strong indicator for the (open or hidden) exclusiveness of an

activity should not mislead to believe that conversely inhomogeneity gives necessarily evidence for inclusiveness (Georgi, 2015). Firstly, we do not know if participants are "typical" for the social group to which they belong. Secondly, we do not know how many individuals from which social group would have liked to participate if they had the opportunity. Thirdly, groups of participants might be inhomogeneous in many respects but very homogeneous in the characteristics that are relevant for the activity. For example, a group of COVID-19 deniers can involve people of all genders, age groups, education levels, professional or cultural backgrounds, but it is very unlikely that all people are equally invited to join their collective endeavours, research-related or not.

In many cases it is not possible to tell if participant groups are homogeneous or not, because participants are not known to the organisers of a citizen science activity, for example, if they are allowed to participate anonymously, as is often the case in crowdsourcing (Pandya & Dibner, 2018, Strähle & Urban, 2021). Even if they are known, asking participants about their socio-economic backgrounds could create a barrier for participation and some/many organizers probably refrain from interrogating participants (too much).

Regarding inclusion/exclusion also organisational aspects could play a role. Depending which institution/s or person/s organises citizen science activities, other some groups of individuals may feel more comfortable or uncomfortable to participate than others. If citizen science is no exception to the common saying "birds of a feather flock together", then one must be aware that any group of people who share interests or characteristics tend to exclude other groups, even if they have no intention to do so. For example, an initiative of environmental activists has probably difficulties to attract motorists' initiatives for the expansion of the road infrastructure. Another issue is in what kind of activities participants are actually included, in which settings and how much power they have. When decisions are taken, for example on research topics and project design or, if research policies are discussed, how realistic it is that everybody has the same opportunities to have a say. Engaging professional facilitators might mitigate the effects of group hierarchies but they cannot fully prevent unequal inclusion.

The most obvious obstacle for equal inclusion is the unequal distribution of resources between citizens. When there is a lack of financial resources, there is often a lack of time resources as well. People who have to work hard to make ends meet are less likely to spend leisure time on volunteer activities. If no attention is paid to the uneven distribution of resources, inclusion can become selective, which calls into question demands that "citizens" should have as much influence as possible when involved in science endeavours to make citizen science as inclusive as possible. In such a case it is almost guaranteed that those who are already advantaged by education, time and financial resources become even more advantaged because their views and interests are promoted.

There is a contradiction in citizen science. On the one hand many scholars and practitioners claim that it is inclusive (e.g., Buytaert, 2014). At the same time there is

some indication that most participants are members of higher or higher middle classes (although there is often no way to tell who the participants are) (Pandya & Dibner, 2018), Haklay, 2013, Füchslin et al., 2019, Strasser et al., 2019). Such a result would not be surprising, because these groups are more likely to possess sufficient resources for voluntary engagement or entertaining their interests and are more likely to have enjoyed an education that made them more interested in scientific topics. This tendency to exclude certain members of society because of their low resources and affinity to science, among other things, is deplored in literature (Dawson 2018):

> *„(…) (T)he field of citizen science is in danger of reproducing the inequities, biases, and underrepresentation that has plagued science. Our interpretation of available evidence suggests that the majority of projects that are being studied/profiled in the peer-reviewed scholarly literature have a participant base that is well-educated, middle to upper class, older in age, and almost entirely white." (Pandya et el. 2018, p. 44)*

Demanding for inclusivity relates to public funding also. If tax payers' money is invested in a citizen science activity, one can demand it gives something back to society. It makes a huge difference if a private club of hobby astronomers stays among themselves and purchases needed equipment with their own money, or if they apply for public funds to buy equipment. In the latter case inclusivity can be demanded as a condition for funding, in the first case, nobody can be forced to open up to the public.

5 Inclusion and exclusion - a matter of contexts

Which forms of inclusion and exclusion citizen can produce depends on the respective citizen science activities and their dimensions, i. e. conditions these activities depend on. And these forms have to be known to assess if an activity should aim at being as much inclusive as possible. Literature research shows that the term citizen science has become (or always was) too broad to allow for meaningful research and analysis in respect to shedding some light on its benefits, caveats, barriers, enablers and disincentives. The many activities performed by different groups of people under multiple possible conditions that are called citizen science need separate investigation. Building on categories, (non-)typologies, reflections on the sensibility or feasibility of such classifications by various scholars and their questions and demands, (Bonney et al., 2009; Cooper et al., 2019; Franzoni & Sauermann, 2014; Haklay, 2013; Haklay, 2018; Prainsack, 2014; Schrögel & Kolleck, 2018; Serrano Sanz et al., 2014; Shirk et al., 2012; Wiggins & Crowston, 2011; Wiggins & Crowston, 2012; Wiggins & Crowston, 2015) and complementing it by additional possible characteristics, the authors compiled a set of activities and dimensions to develop the Activities & Dimensions Grid of Citizen Science. The activities are grouped into four areas. The appropriate unit to

analyse citizen science is not a project, but an activity. Each activity within a project can show a different profile of characteristics.
In the following some areas of citizen science activities and some of their respective dimensions are regarded under the aspect of inclusion or exclusion.

5.1 Area 1 Input for research policy

Activities in these areas are not about doing research or innovation, but they are about decision-making in politics. Even if participants have no real political power, all deliberative formats can directly or indirectly influence political decisions. Citizen science in this area is a form of what is considered as participatory democracy by many policy makers; however, it is a term that is quite differently understood (Council of Europe, 2022, Abels, 2009).
In the following we do not talk about referenda but different formats in which “citizens” or “civil society” (sometimes civil society organisations are included) deliberate on political issues, such as citizen juries, consensus conferences, planning cells and scenario workshops. Such formats dealing with science-related issues have gained popularity and are now dubbed citizen science. Some formats have been developed and used in the context of urban planning. (Traces of this origin can be found in Arnstein’s “ladder of participation” (Arnstein, 1969), which was very popular among citizen science advocates. Hopes and concerns about participatory democracy in general are valid for participatory activities in research politics as for other fields of politics.
The field of citizen deliberation for policy making is still in an experimental phase and optimal formats have not been found yet. To avoid voluntary arbitrary selection, there is some experimentation with sortition, e.g., randomly selecting participants from a pool of people who fulfil certain criteria and/or are willing to participate and providing sufficient resources to make participation possible for those who normally could not afford to do so. Examples for citizen consultations are consultations on Cohesion policy organised by the European Commission (European Commission, 2022).
Even if it is decided by lot who participates in a deliberative event, i.e., is included in or excluded from deliberation, it is still the question how much financial support should be provided and in which form to make participation of less resourceful people possible. Remunerating travel costs and stay may not suffice. And even if sortition is applied and all necessary support is given to economically weaker participants, not all problems are solved. There remains potential strong influence on the outcomes by those who organise deliberative events: because of an organisers’ effect we postulate, as we suppose there is an effect caused by how an organiser of such deliberations is perceived by potential participants, the compilation of information material, the choice of facilitators, reporting and documentation, to name a few. There is still a long way to go to experiment with formats that could minimize such influences.

5.2 Area 2 Scientific research

This area comprises all activities in which non-professionals contribute directly to specific projects or initiatives by carrying out scientific or science-related tasks without being (substantially) paid for their work. Most of the contributors are volunteers, but of course one never can rule out hidden dependencies, group dynamics or power structures that could create (conscious or unconscious) pressure on individuals to participate. Caution demands to ask if (all) volunteers are included fully voluntarily in a specific project and to scrutinize it for any traces of involuntariness.

There is a broad range of activities that can be performed by untrained participants, and many categorisations, typologies or models distinguish forms of citizen science by the steps of research in which citizens are involved. Building on such models the Activities & Dimensions Grid of Citizen Sciences includes such a classification by activities (see Table 1).

Table 1: Citizen science activities (Strähle & Urban 2021)

Area 1: Research Policy	
Deliberation, consultation, etc.	*Inclusion of high importance.*
Area 2: Participating in research	
Determining research questions	*Inclusion of high importance.*
Research design	*Inclusion of high importance.*
Data collection	
Data preparation & processing	
Retrieval of scientific literature	
Experimenting	
Knowledge management	
Analysis & problem solving	
Reviewing & evaluating	*Inclusion of high importance.*
Action research	
Passive participation	
Area 3: Development & inclusion	
Technical development	
DIY biology	
Area 4: Citizen science in schools	
All activities in the Areas 1-3 are possible.	*Inclusion of high importance.*

Some authors even suggest that citizen science should involve citizens in all tasks of a project, often based on the assumption that data collection would be a very basic form of participation. For example, Haklay's elevator (Haklay, 2018), which is based on Kleijssen et al. (2017), presents a hierarchy of activity-based forms of participation in scientific projects. The idea behind this is that participation high on the elevator is more inclusive and desirable than in those low on it.

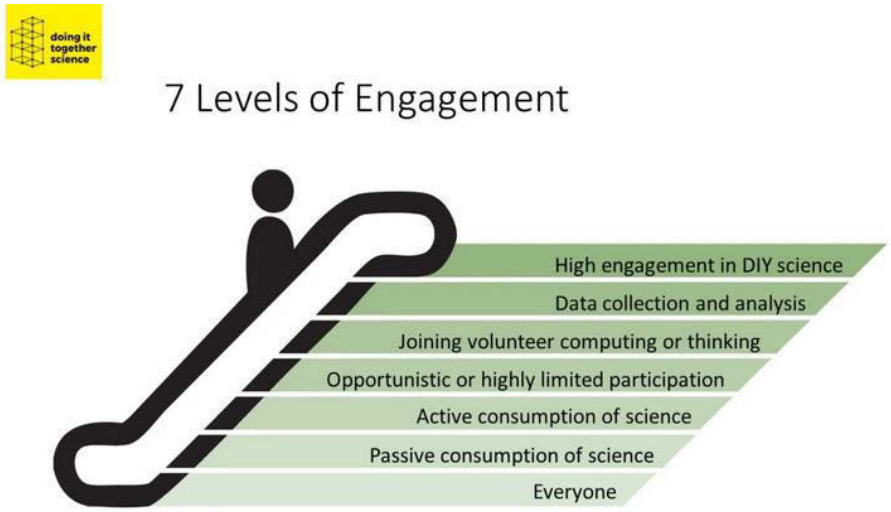

Figure 1: Escalator of engagement levels (Haklay 2018)

Put to extremes this approach says: The more the roles and the activities of the citizen scientists resemble those of the professional ones the better. We call this the strong idea of inclusive citizen science. The question remains who polices the boundaries between citizen and professional scientists. It can be fairly assumed that usually the professionals to police the inclusion of non-professionals. This version has to answer to some questions: Apart from being satisfied with having contributed to something participants consider as a meaningful activity, what can they gain from it? Does it have a positive impact on their lives and, even more important, on society as a whole? How much power do participants have to influence the research that is carried out? These questions are far from simple to answer. Most obviously, those participants are in a powerful role who have a say in the research questions. The same can be said about co-determining the project design. The possible influence in other activities vary largely. For example, although it may be true that many projects have participants performing seemingly easy tasks, like taking photos and sending them to the project owners, in many cases collectors of data need to be skilled and knowledgeable. Each of them can impact on the results of a research activity, sometimes profoundly, especially in small projects, for example, if they hold back information. (Pocock et al., 2017). If they conduct interviews, they can influence interviewees. Hence, one cannot generalise on inclusion but has to take the potential influence into account. If there is no substantial power for influencing a research project and participation in a project means that resourceful people donate their time without gaining more than personal satisfaction, why should it be problematic if people who do not possess sufficient resources are de facto excluded? The difficulty rather lies in determining if both conditions are met.

5.3 Area 3 Development & Innovation

The more recent addition of this area to the realm of citizen science broadens the concept considerably. This area includes development and innovation activities which can also take place in fab labs, DIY laboratories and hobby garages. Invention can take place in a wide range of fields: DIY Biology, usability testing, engineering, software programming, just to name a few. The motivation for participating is probably mainly rooted in making concrete products rather than in producing knowledge. The boundaries between reproduction of existing products and making something new may be difficult to draw, as both can happen side by side at the same locations (in fab labs, private laboratories, hobby garages, etc.). Because activities might result in new products or improvement of existing products, it can potentially lead to economic gain for some participants. This makes the question of inclusion to a question of just distribution, too. If public funding is involved, equal access to tools, infrastructure and technical support for all who want to innovate and develop can be asked for. It may be equally important to establish clear rules for any economic exploitation of innovation.

5.4 Area 4 School projects

School projects in citizen science are presented as a means to interest children in science & research, especially STEM disciplines, to increase the number of STEM graduates in fields for which a future demand of a high number of professionals is anticipated (Gough, 2015).

By some authors (e.g., Ruiz-Mallen et al., 2016), school projects with pupils are seen as more successful in involving participants with low education backgrounds and thus more inclusive than other projects. Irrespectively, if we are dealing with research policy making (area 1), participating in research or DIY activities, schools have (or should have) as a first goal to teach children according to a curriculum, who have a civic right to get as good an education as possible. Hence, in schools, citizen science becomes a didactic tool and inclusiveness has to be evaluated under this perspective. In case a specific citizen science activity with specific characteristics proves appropriate as a teaching method, it has to be asked if it works equally well for all participating children. Just being physically there does not yet prove that a child is included. It is also possible that pupils coming from highly educated families benefit more from some modern learning and teaching methods than pupils whose families have less affinity to education.

6 When is inclusion important?

Exclusivity can be more ethical than inclusivity, for example, if special skills are needed or longstanding trustworthiness has been proven by participants who are to operate in sensible biotopes, to handle fragile archeologic artefacts, deal with rare species, etc. If there is access to sensitive private data of other participants or if there is a potential

risk for the physical or mental health of participants, the activity might not be appropriate for citizen science, require experts and demand for total exclusion of lay persons. Exclusion can be also more ethical, if an individual asking to participate has personal conflicts of interests, which is not a specific issue of citizen science but a problem that receives much attention in "traditional" research.

Where a citizen science activity takes place obviously has an effect on who can be included. Online activities can mitigate or exacerbate inclusiveness. On the one hand, people who are less mobile or live in remote areas have better chances to participate, if they can participate online. On the other hand, if expensive hard- or software is required or a high-speed internet connection, this tends to exclude people with lower incomes and create a digital divide, especially in online citizen science.

It is remarkable that the focus on inclusion in science leans towards giving citizens the opportunity to do voluntary work, while many are excluded from studying at universities for merely financial reasons and remain widely excluded from a well-paid professional career in science. In a nutshell, inclusion is not an important aspect of a citizen science activity as long as the role of citizen scientists is similar to those of volunteers in charity work, who do not steer a project, and involving citizens, who are rarely involved in research, is not an important aspect of the research to be performed. However, their workload may be important here. Are they exploited as a cheap labour force (Mirowski, 2017)? Are paid jobs eliminated by the volunteer activities? Is there an appropriation of extensive knowledge of "non-scientific" experts, e.g., traditional ecological knowledge? (Walajahi, 2019)? And last but not least, what is the political, economic and cultural context of an activity? Does it strengthen non-egalitarian power structures? How may it impact on a community in which it takes place?

For obvious reasons, citizen science is not inclusive simply because non-specialists, sometimes imagined as being in need of science education, are invited to contribute to scientific projects. For instance, "participatory" agenda-setting in science or more time-consuming contributions can advantage even further those who are already cumulatively advantaged. On the other hand, as long as citizens have no more control over a project than volunteers in charity contexts, inclusion might not play such a crucial role. The example of citizen science shows that the requirements for democratic participation of citizens in scientific research and research-relevant decision-making processes are many times more complex than commonly assumed. Among other things, the question arises who is targeted. Probably citizen science advocates do not intend to provide a platform for anti-vaccination activists.

7 Overpromising

Notwithstanding the benefits and potential citizen science has for crowdsourcing, especially in biodiversity research, and science education, the claims that citizen science is inclusive per se, democratises science and enhances public understanding

of science among those who participate in citizen science activities are too general and insufficiently substantiated to be taken at face value. Similar claims have been made about public engagement activities (Stilgoe et al., 2014), and there are similar debates in Responsible Research & Innovation (RRI), although more critical ones (e.g., see van Oudheusden, 2014, Bauer et al., 2021, van Mierlo et al., 2020). It would be worth a research project of its own to compare the promises of and the debates on inclusion in RRI, citizen science and public engagement in science.

Perhaps citizen science is another manifestation of the "participatory turn" (Jasanoff, 2003), the turn away from initiatives to promote public understanding of science that aimed at putting down public controversies on GMO and other controversial topics by informing publics policymakers imagined as uninformed and reacting only emotionally. Since about 2015 citizen science moves up on the totem pole of policymakers. It appears to be an answer to failing campaigns to promote public understanding of science and to the limitations of public engagement with sciences and the overpromising of those who pushed for it. However, we may witness a similar overpromising as in the case of former initiatives of public engagement in science here, which made quite similar claims in a similar manner (Stilgoe et al., 2014).

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Corresponding authors

Dr Michael Strähle, ms@wilawien.ac.at, ORCID ID 0000-0002-4011-2619
Mag[a] Christine Urban, cu@wilawien.ac.at
Wissenschaftsladen Wien – Science Shop Vienna
Währinger Straße 59
1090 Vienna, Austria
https://wilawien.ac.at