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Supporting emerging forms of citizen science: a plea for diversity, creativity and social innovation

Teresa Schäfer and Barbara Kieslinger

Abstract

In recent years, citizen science has gained popularity not only in the scientific community but also with the general public. The potential it projects in fostering an open and participatory approach to science, decreasing the distance between science and society, and contributing to the wider goal of an inclusive society is being explored by scientists, science communicators, educators, policy makers and related stakeholders. The public's participation in citizen science projects is still often reduced to data gathering and data manipulation such as classification of data. However, the citizen science landscape is much broader and diverse, inter alia due to the participation opportunities offered by latest ICT. The emergence of new forms of collaboration and grassroots initiatives is currently being experienced. In an open consultation process that led to the "White Paper on Citizen Science for Europe", the support of a wide range of project types and innovative forms of participation in science was requested. In this paper we argue for mechanisms that encourage a variety of approaches, promote emerging and creative concepts and widen the perspectives for social innovation.

Keywords

Citizen science; Participation and science governance; Public engagement with science and technology

Introduction: citizen science, a core concept with a wide range of instantiations

Citizen science or the involvement of volunteers in authentic scientific research, has gained a good deal of attention in recent years, especially with the communication, collaboration and networking possibilities offered via the Internet. Interest seems to be growing within the scientific community, across the general public as well as amongst political stakeholders. In this paper we would like to stress the big diversity of projects in terms of degrees of participation and desired outcomes that are embraced under the concept of citizen science. Based on the heterogeneity of these projects and their different intentions, a complex set of demands arises regarding their coordination, evaluation, impact assessment and possible support structures. During a public consultation process leading to a White Paper on Citizen Science for Europe [Serrano Sanz et al., 2014], the collected data from divers citizen science actors confirm the heterogeneity of the field. Thus we take a strong advocacy of diversity and creativity in citizen science based on what we learned from the citizen science community. If the field of citizen science remains divers,

open and supportive for the manifold forms of cooperation between citizens and scientists we can benefit from the numerous potentials it holds for science and society.

From scientific questions to societal changes and vice versa

As soon as one starts to investigate the field of citizen science it becomes clear that this term comprises manifold activities and approaches that somehow link the public with scientific research. Wiggins and Crowston [2015] recently stressed the diversity found in observational citizen science projects in terms of participation, social opportunities etc. Still, we believe the diversity is becoming much broader, as citizen science embraces a wide range of project types. At one end of the spectrum, citizen science encompasses activities that involve citizens as rather passive contributors to scientific research. Citizen science projects are described by some as "partnerships initiated by scientists that involve non-scientists in data collection." [Jordan et al., 2011] or as "field assistants in scientific studies" [Cohn, 2008, p. 193]. At the other end, it comprises approaches that require researchers to immerse themselves into local communities, to closely collaborate with local actors and citizens, identify research questions and use their scientific skills in order to solve relevant issues of today's society [Mueller, Tippins and Bryan, 2012].

Due to the development of sophisticated Internet applications which effectively utilise crowdsourcing for data collection over large geographic regions, citizens science is experiencing considerable expansion [Dickinson, Zuckerberg and Bonter, 2010]. What has changed according to Jennifer Shirk from Cornell's Laboratory of Ornithology [Cohn, 2008, p. 193] are the "number of studies that use citizen scientists, the number of volunteers enlisted in the studies, and the scope of data they are asked to collect". At the same time, advances in data storage and web technology are making the increasing amount of collected data including images and audio(-visual) files easier for volunteers to access. Social networking technologies such as forums and blogs are allowing communities to form around a shared interest in scientific research [Raddick et al., 2009].

However, it is not only technology that has changed the scale and scope of citizen science. A growing number of researchers criticise the dominating model of volunteers as mere "data drones" and demand a more engaging role for citizens [Hemment, Ellis and Wynne, 2011, p. 63] that allows for true collaboration between scientists and participants; which is said to be often missing in traditional top-down projects. Due to these different understandings and activities subsumed under the term "citizen science", first attempts were undertaken to identify typologies of citizen science projects.

Shirk et al. [2012] proposed speaking of "public participation in scientific research" (PPSR) to cover the different contexts and traditions in which the public can become involved in scientific research. They define "PPSR as intentional collaborations in which members of the public engage in the process of research to generate new science-based knowledge" [Shirk et al., 2012, p. 29] and cluster PPSR projects according to (1) the degree of public participation in the research process and (2) the quality of public participation as negotiated during project design. Wiggins and Crowston [2011] elaborated another typology of citizen science

projects where they not only focus on types of scientific tasks performed by volunteers or the degree of their involvement, but they also consider organisational characteristics, enabling technologies, and goals of projects. Both classification schemes presented above do not explicitly include what is commonly labelled as "volunteer computing" in their definitions of citizen science. Wiggins and Crowston [2011] argue that in their understanding, providing computing resources is not part of citizen science as volunteers are only involved passively in scientific work. On the contrary, we believe that volunteer computing projects can be seen as those citizen science projects, which require the lowest amount of effort from citizens [Socientize Consortium, 2013].

Looking at the different typologies we aim for an inclusive view (see Figure 1.) as we think that different needs for support and action for different types of citizen science projects are arising; also relating to how close or how far they are from established forms of research. In our understanding, there are two important aspects of differentiating instantiations of citizens science: 1) the locus of knowledge creation — moving along a continuum from projects where knowledge creation is mainly in the hands of researchers to those where citizens are the main knowledge producers; 2) the focus of project activities — moving from research driven projects with a core aim of answering scientific questions to projects that focus on supporting interventions in socio-ecological systems. Placing existing typologies of citizen science in a matrix and reflecting on the two aspects gives the following picture:

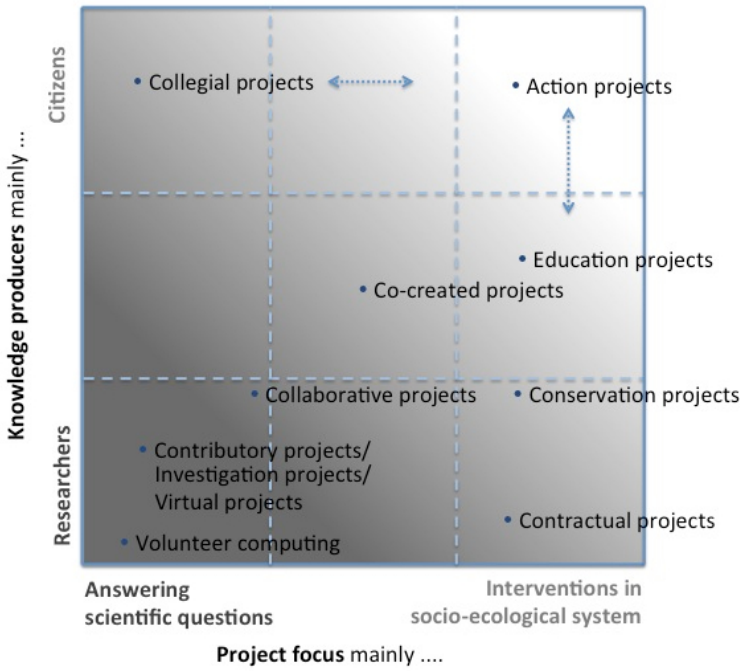

Figure 1. Types of citizen science projects (integrating citizen science typologies from Bonney et al. [2009], Shirk et al. [2012] and Wiggins and Crowston [2011]).

In the left lower corner of Figure 1, we find projects that are mainly driven by the desire to answer scientific questions. Researchers are the drivers and main creators of scientific knowledge in this type of project while citizens support certain phases of the research process by executing well-defined tasks (e.g. data collection). Projects that fall under this category are closest to "traditional" forms and

institutions of doing research. One of the biggest and best known projects of this type is *Galaxyzoo*,[1] which involved 150.000 citizens in its first year and refers to 50 million classifications of galaxy images.

Moving along the axes, the influence of society increases: either as a driver for specific scientific questions (horizontal axis) or as a producer of knowledge (vertical axis). Projects that are in the right upper corner category consist of those where citizens are the main creators of new knowledge whose aim is primarily to support citizens' grassroots and bottom-up initiatives. Projects in this area are closest to civil society organisations. Experts assign these initiatives, sometimes also called "extreme" citizen science, as having real potential for social change as it is the communities, which express their needs for action and are involved in all stages of the scientific practice [Cunha, 2015]. An example for this type of collaboration between science and society comes from North America, where after the BP oil spill disaster in 2010, volunteers started to document the extent of environmental damage and researchers were involved in the collaborative development of portable measurement instruments for citizens.[2]

In the middle of the matrix we have placed projects that are based on mutual learning and collaboration between researchers and citizens during all project phases. Ideally, all actors work together in an equal partnership during the whole process. A European case study for this type of project comes from England where in the project *Royals Dock Noise Mapping*,[3] residents in the Royal Docks of London collaborated with the University College London to collect their own noise readings and bring evidence of disturbingly high levels of noise due to the operation of the London City Airport. The collected data formed the basis of a local campaign group's submission of a legal challenge against Newham council's decision to approve the expansion of the London City Airport.

"Contractual projects" [Shirk et al., 2012] are projects, where scientists are "contracted" to serve civil-society initiatives and are responsible for scientific knowledge creation. European Science Shops[4] are typical facilitators for such projects, since they take on research based on the needs and demands coming from civic society. "Education projects" [Wiggins and Crowston, 2011] have a clear educational aim and focus on the volunteers' learning gains on a specific topic or scientific method. They also tend to support science communication. An exemplary project is *Fossil Finders*,[5] where pupils are involved in the investigation of Devonian fossils. The core activity of students is to classify and describe fossils in rock samples that are sent to classrooms. Accompanying support material for teachers, a discussion forum for pupils and researchers and the sharing of results between schools are framing the research activities. In Austria the Federal Ministry of Science, Research and Economy launched a whole programme on educational citizen science projects under the heading "Young Citizen Science".[6]

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[1] http://www.galaxyzoo.org.

[2] http://www.fastcoexist.com/3025300/how-the-bp-oil-spill-launched-a-movement-to-investigate-pollution-with-diy-tools.

[3] http://mappingforchange.org.uk/projects/royal-docks-noise-mapping/.

[4] http://www.livingknowledge.org/livingknowledge/.

[5] http://fossilfinder.coe.uga.edu/.

[6] http://www.youngscience.at/fileadmin/youngscience/Fotos/Young_Citizen_Science/Young_Citizen_Science_Research_with_the_help_of_young_people.pdf.

In the left upper corner of Figure 1, in for instance "Collegial projects" [Shirk et al., 2012], citizens are responsible for the self-contained answering of scientific questions. Collaboration with scientists is limited to the validation of the newly created knowledge. An extension of the *Galaxyzoo*[7] could be cited as an example here. Next to the simple task of clustering galaxy images, citizens were provided with access to the research data. Based on the data volunteers defined and worked on their own research questions, which also resulted in scientific publications from citizens. This approach shows that projects can integrate several types of citizen involvement. *Natural history associations* are further examples for this type of collaboration.

Compared to existing typologies of citizen science that are fixed and limited to a certain number of types and descriptions [e.g. Bonney et al., 2009; Wiggins and Crowston, 2011; Shirk et al., 2012] we understand our categorisation via this matrix approach as more flexible. It allows a more permeable and dynamic view, where projects find themselves initially in one of the sectors, but can move along the two axes into other sectors or stretch across sectors, similar to Haklay's typology that focuses on different degrees of participation [Haklay, 2013].

Positioning projects and activities in the matrix helps to identify the different challenges citizen science is facing. Projects in the upper sector of the matrix, where citizens gradually take on a lead role along the process, have to think about new ways of integrating emerging knowledge produced by laypersons into the scientific knowledge landscape. We have to find ways of dealing with intellectual property and ascertaining scientific rigour in doing things. Projects in the lower sector of the matrix, where the citizens' role is limited to certain types of activities in the scientific process such as data gathering, are facing a need to reflect on whether they are harvesting from the full potential of such collaboration. Furthermore, we need to explore if and how we can engage citizens as real experts and consider new ways of optimising this integration by offering steps towards a more active form of participation.

On the right side of the matrix, where we find projects supporting interventions in socio-ecological systems, the innovation aspect for research has to be considered carefully, while on the left side, where we position projects that have a focus on answering scientific questions, special attention has to be given to the additional societal impact of research activities. If we want to harvest the full potential of citizen science, for any type of citizen science project we must consider its potential impact on science, but we also need to explore its ripple effects on society and social innovation. In the following sections, we will reflect on these aspects and connect them to the field experiences that emerged during an open consultation process in 2013–2014.

[7] http://www.galaxyzoo.org.

What are citizen scientists struggling with? What kind of support do they need?

In the context of SOCIENTIZE,[8] a project funded by the European Union to promote citizen science in Europe, a public consultation process was launched to prepare a first White Paper on Citizen Science for Europe [Serrano Sanz et al., 2014]. Based on a literature research, nine interviews with experts from Europe and North America were conducted and an open call for contributions was launched. 27 European stakeholders in research and science communication contributed to identify a first set of emergent trends, exemplary cases of citizen engagement in research activities and in scientific policies, open questions and recommendations. This input led to the Green Paper on Citizen Science for Europe [Socientize Consortium, 2013], which formed the basis for an open online consultation process. During three months (from February to April 2014) of consultation the most urgent 15 questions from the Green Paper were further discussed with the citizen science community, and a set of recommendations put under evaluation. The resulting White Paper builds on collective knowledge by involving international experts and amateurs alike. Most importantly, during this process, we encountered a very heterogeneous landscape composed of complex multi-actor, multi-level, trans-disciplinary communities, which is sometimes reflected in controversial or contradictory statements by the approximately 200 participants of this consultation process as regards to the way forward with citizen science.

A very controversial discussion revolved around the question of how to frame the definition of citizen science: Should we come up with a single and commonly accepted definition for citizen science or not? The confrontation between experts representing contributory or investigation projects and experts coming from action projects highlighted the manifoldness of citizen science initiatives with regard to objectives, collaboration forms, applied instruments, scale, etc. In the end, the discussion led to the conclusion that we should not aim for one single definition of citizen science but rather a series of definitions that reveal the dynamics of this research approach. Experts agreed that citizen science processes are continually evolving thus implying new collaborative activities and shared objectives between the main stakeholder groups.

One of the major bottlenecks according to all key actors in citizen science is financial support; not only for initiating and running projects, but also for maintaining and sustaining initiatives in the longer run. Figure 2 shows how the community rated the importance of a set of policy recommendations that were drafted based on the initial consultation with stakeholders in the field [Socientize Consortium, 2013]. The result is based on 103 individual answers that were provided via an online questionnaire, which was sent out to major players in the field of citizen science and science communication in Europe. Respondents were approached via direct mail as well as social media links and the promotion of the questionnaire in the official newsletter of the European Commission.

As reflected in Figure 2, the most prominent requests from the community during the consultation process refer to concrete *project funding on multiple levels (regional, national, European)* in order to fully benefit from the positive outcomes of this research approach for research and society. Funding mechanisms are requested 1) for a genuinely new citizen science programme, 2) for supporting the integration of citizen science in established funding schemes as well as 3) for the provision of long-term financial support of basic infrastructures.

[8] http://socientize.eu.

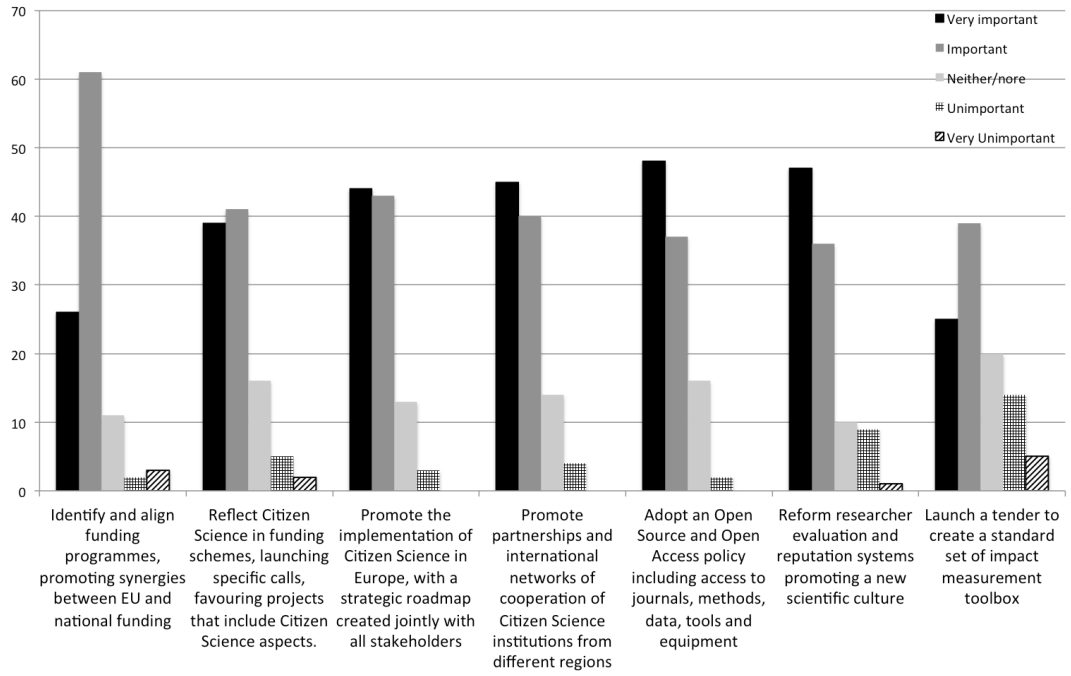

Figure 2. Results from Online Consultation Questionnaire: Rating of first recommendations (n=103).

The community also identified the clear need to organise and facilitate *opportunities for knowledge exchange* between all stakeholders involved. An exchange of good and bad practices coming from different types of citizen science projects as regards to involvement strategies, impact assessment, data quality and access, intellectual property, technical features and sustainability was requested by many. Shared experiences could also serve as the basis for the *development of facilitation material and activities* to foster the broader dissemination of citizen science towards both the scientific community as well as the public. Initiatives for collaboration and networking have already kicked off, such as the Citizen Science Association and the European Citizen Science Association (ECSA) as well as national platforms. In how far these consortia can take on a leading role in providing collaboration structures in the wider sense will depend again on sustainability and funding mechanisms.

Another important element in fostering citizen science is an *appropriate incentive system* for all stakeholders involved. Intrinsic motivation is certainly the best base for a successful and long-term involvement; nonetheless, external incentive systems tend to add to these intrinsic values. An institutional recognition of activities that involve citizens in science is an important step from an academic perspective. However, actual *scientific value systems* in universities and scientific institutions rarely consider the recognition of participative and social activities. An introduction of a "social impact indicator" comparable to publication indicators could increase the motivation of scientists to participate in citizen science projects. Likewise, incentive systems e.g. in the form of public awards, prizes, as well as specific benefits or privileges that recognise the citizens' contribution can increase motivation for participation on the volunteers' side. The above-mentioned Citizen Science Associations might consider leading a discussion on the recognition of participative and social activities and raise wider awareness.

A huge controversy around evaluation and impact assessment arose during the consultation process. Whereas there was some basic agreement that being able to demonstrate impact of any citizen science initiative is important and can benefit the whole field of participatory research, there were some strong voices against any standardised evaluation criteria to be applied across all projects. In addition, the need to keep citizen science flexible and thus adapting evaluation strategies to particular projects was clearly stressed by a large number of experts.

What does that mean for diversity, creativity, and emerging participation?

In our plea to support diversity and creativity in citizen science, we would like to see support for the full range of project types shown in Figure 1 as well as for new and emerging forms of civic participation. What can we learn from the consultation process?

Basically, openness towards all forms of citizen science needs to be reflected on a macro-, meso- and a micro-level (see Figure 3). Coupled with that, strategic policy-making needs to consider inclusive programme designs and funding mechanisms. Furthermore, there is a clear need for more collaboration and mutual learning at the community level while at the level of the individual citizens and scientists education and training is core.

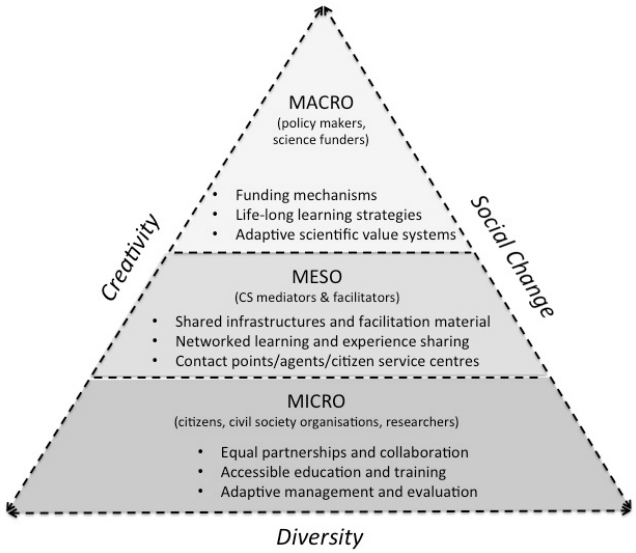

Figure 3. Openness on the macro-, meso-, and micro-level.

When we talk about funding, agencies should consider a funding programme for citizen science projects that aims to collect the manifold experiences from the different project typologies of this ever evolving research methodology and that creates visibility for the potentials of citizen science for researchers and the public. To benefit from the full range of outcomes, such a programme would need to be open for all different types of citizen science projects and thus support next to science-driven projects (in the lower left section of Figure 1), also those activities, which are initiated by citizens or civil organisations (moving along both axes in Figure 1). A clear challenge to design a programme that allows participation of "grassroots" initiatives, which are driven by civil society organisations or by independent citizen scientists, therefore presents itself. The level of bureaucracy

and the required institutional backgrounds also need to be considered carefully. We need to move away from the standard funding channels and look more into alternatives, e.g. channels similar to crowdsourcing models, which seem to be closer to grassroots initiatives. A shift from the classical focus on natural science towards other disciplines such as social science or humanities should likewise be championed and thus accordingly reflected in mobilisation campaigns.

In the long run, citizen science should not be seen as separate from other research areas but as an integral part of existing scientific activities comparable to science communication. Thus the involvement of citizens could become one of the selection and evaluation criteria in existing funding schemes. The challenge in designing this measure is trying to avoid discriminating against those research projects that are difficult to communicate to citizens, thus we see the need to motivate the involvement of citizens in projects instead of obliging projects to do so. A differentiated approach in the selection processes is therefore important by allowing citizens to be also directly involved in the selection process for funding.

We believe that aside from funding of concrete projects, the development of infrastructures on regional, national and international level is key to success. In recently established citizen science associations and forums, we have noted a prevalence of research driven projects dominated by natural sciences, possibly due to the history of these associations. Careful attention should be given to the expansion of these networks so as to integrate all types of citizen science projects from various disciplines and diverse initiators including especially bottom-up initiatives. We need to showcase the broad range of participation and action that citizen science offers and advocate scientific citizenship, including a shift of responsibility from research to society. If we find new ways of acknowledging "lay"-knowledge we may open up new opportunities for creativity and for finding innovative solutions to our societies' challenges. Combining scientific rigour with the practical knowledge of citizens who are the experts of their "Lebenswelt" (engl. living environment, everyday life) has great potential that we still have to explore further. Only by considering citizen science as a tool for empowering citizens and by supporting interventions in socio-ecological systems can we exploit the full potential of citizen science.

Education clearly plays an important role in the whole process. We envision citizen science instruments and methods being reflected in curricula for young scientists and even going beyond that. The active collaboration between scientists and citizens should begin at an early age. Schools are in this regard a great place to start fostering citizens' autonomy and *responsibility for change through lifelong learning* as expressed by some innovation experts.

Final remarks

As indicated, there is a clear need to support all different types of citizen science projects and to offer support in the conceptualisation and design of emerging new forms of citizen engagement. Although participants of the consultation favoured different types of citizen science projects, there was a clear consensus that policy makers as well as citizen science mediators and facilitators should not restrict their support to any specific type of projects. From our experiences to date, citizen science still holds the potential for new, creative and experimental forms of participation, especially considering the possibilities offered by latest technologies.

It is important to provide enough creative space where grassroots initiatives can flourish side-by-side with more established forms of scientific knowledge production and a platform where the community can meet and exchange ideas so as to establish fertile grounds for the broader dissemination and uptake of this collaboration between citizens and scientists.

In more concrete terms, we recommend bringing support measures down to local and regional levels where the grassroots initiatives respond to socio-ecological demands that arise from specific group needs. New forms of citizen service centres that are embedded in the local context might also serve as interfaces for citizens to be informed and support any emerging initiatives that would benefit from a participatory scientific approach. Teachers are well positioned in taking on an integrative role: being naturally anchored in the culture of the local community, they could extend the meaning of teaching and scientific learning beyond the classroom borders and become, alongside the community, active agents of democracy and change. Thinking even further, we envision potential promoters for citizen science in local municipalities and administrations. Local service agents could provide the link to science as a complementary form of citizen service. This can support not only the most popular natural science driven projects, but also provide encouragement and help for citizen science initiatives that have a greater focus on social innovation and social change, defined as the processes of change in social structures, institutions, culture, behavioural patterns and states of consciousness [Hochgerner, 2013].

While a recent editorial in Nature [Nature, 2015] expressed concerns about the conflicts of interest that arise when research is driven by volunteers' objectives, we argue strongly in favour of supporting projects that address societal issues and are driven by concerned citizens. The editorial conveyed doubts about the motives and ambitions of citizen scientists in bottom-up initiatives that might be politically motivated, such as pollution tracking to oppose current fracking practices. Contrary to the view expressed by the editors, we believe that such research is equally legitimate like any other type of research as there is no entirely value-free approach to science. Only if we allow citizen science to grow in all its multifariousness, has it the potential to drive scientific citizenship and social innovation.

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