Item number	Title/reference *(academic style) name initials (year) title, publisher, volume, pages*	Name of reviewer
19	Roche, J., Bell, L., Galvão, C., Golumbic, Y.N., Kloetzer, L., Knoben, N., Laakso, M., Lorke, J., Mannion, G., Massetti, L. and Mauchline, A., 2020. Citizen science, education, and learning: challenges and opportunities. Frontiers in Sociology, 5, p.613814.	Karl Donert, EUROGEO

Review of findings / main outcomes

This paper identifies a number of dilemmas including competing scientific goals and learning outcomes, differing underlying ontologies and epistemologies, diverging communication strategies, to clashing values around advocacy and activism. It is important to consider the potential of citizen science to foster education and learning opportunities.

Bela et al., (2016) say that every person who participates in citizen science is involved in a learning process. This relates not only to the acquisition of participatory skills, but also those of "scientific literacy", that enable a deeper understanding of scientific concepts and processes.

The authors suggest citizen science can function as a means of engaging the public with science on the scale of individual experiments, creating a unique position of combining participation, monitoring, and social change (Dawson et al., 2020).

Arnstein (1969) pioneered the concept of citizen participation with her "Ladder of Citizen Participation," which described the eight levels of citizen power, from non-participatory "manipulation" to "citizen control".

Haklay (2013) suggested citizen participation enables all stakeholders to collaborate. As participants learn more about the scientific projects they are involved in, they are likely to move from merely acting as data gatherers for science projects, to collaboratively shaping scientific activities from their inception, and participating in their analysis throughout. At this level, citizen science would emerge as a truly transformative practice that has the power to change and influence the world.

Reis (2020) confirms citizen science can play an important role in activism and in advocacy, with citizens intervening on behalf of a cause to engage with policy and bring about social change. From this perspective, citizen science should encourage individuals to take an active citizenship role in their communities (Burls and Recknagel, 2013). This role is especially relevant in projects that focus on environmental activism and climate change (Kythreotis et al., 2019), empowering people to take responsibility for the future of their communities and by sharing results through social media influence the actions of decision-makers.

One of the key recommendations is that citizen science projects should align educational learning outcomes with the citizen science project goals at the planning stage. This can be done using co-creation approaches to ensure that issues of inclusivity are considered throughout the project design and implementation. The co-creation processes allow citizen science to empower citizens to take ownership of their own science education and learning.

In Europe, The European Citizen Science Association has highlighted education and learning as critical features for citizen science to consider. Those involved in projects should identify the challenges and opportunities that arise when citizen science and education are brought together.
This paper introduces the online platform EU-Citizen.Science, a web site for citizen science in Europe established with the support of a Horizon 2020 grant from the European Commission. The purpose is to make citizen science projects and data more readily accessible and act as a mutual learning space

for sharing useful tools, guidelines, training, and best practice examples in several languages to help citizens, scientists, teachers, students, schools, and other stakeholders to determine when and how they can engage with local and international citizen science projects.

Quotes / very useful statements

"Informal learning environments, such as science centres and museums, are critical to science education. Citizen science projects find a natural home in these domains due to a shared strong commitment to public engagement."

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