Citizen Science for Social Decision-Making: Avoiding Missteps and Unlocking Potentials

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Abstract

Citizen science that is, involving the public in scientific inquiry has increased with an expected use in social decision-making as a democratized scientific method. Despite the success of citizen science projects, such as enhancing the public understanding of science and contributing to social well-being, the use of these projects in social decision-making is constrained due to an inherent issue, namely, *bias*. A critical challenge lies in the limited role of citizens in these projects, which impacts social decision-making. The representativeness of participants is a concern, because projects frequently attract a specific demographic, which can lead to results that are inapplicable to the broad population. Other issues include geographical and temporal representativeness, as well as the lack of accessibility and inclusion, which can exclude individuals without the necessary resources for participation. Additionally, a superficial involvement of citizens exists in the research process. Citizens are typically only involved in data collection and occasionally analysis, which leaves the crucial stages of design and interpretation to researchers. This scenario could also lead to results that are misaligned with community needs or values, which, hence, limits a genuine contribution to democratic and socially relevant decision-making. To realize the democratized scientific method, citizen science needs to extend beyond mere data collection and engage citizens in all aspects of the research process. By embracing these challenges, the future of citizen science could significantly impact society.

Key words: community based, decision-making, demographic way, inclusive, social problem

Introduction

In recent years, scientific evidence is one of the key factors of social decision-making (Lee 2010; Turner et al. 2022). Furthermore, the call for public involvement in social decision-making, such as establishing policy in line with democratic ideals, has increased (Rowe and Frewer 2000, 2005). *Citizen science* is typically heralded as a mechanism for greater public engagement with scientific research (Hollow et al. 2015; Hecker et al. 2019). This view leads to the assertion that citizen science may foster public input into social decision-making (Bonney et al. 2014; Hollow et al. 2015; Kobori 2022).

In fact, a number of previous studies suggested that citizen science projects can contribute to social decision-making in various ways. For example, Hollow et al. (2015) demonstrated that a citizen science project enabled the collection of a wide range of opinions, which helped in the discovery and definition of relevant issues on management and conservation policies for koalas (Hollow et al. 2015). Bonney (2016) cited that citizen science can contribute to the public understanding of science and positively contribute to social well-being (Bonney et al. 2016). Tiago (2017) mentioned that guiding policy goals and decisions is one of the crucial factors of the appropriate design of citizen science projects. Therefore, citizen science projects hold the potential to engage the public in scientific research and contribute to social decision-making.

Scholars consider citizen science as a means of democratizing science and enhancing public engagement (Bonney et al. 2016; Hecker et al. 2019). Indeed, it offers significant potential in extending the reach and applicability of scientific research. To the best of our knowledge, however, discussions on the challenges related to citizen science for social decision-making remain few. Several studies have been conducted on the

challenges for citizen science, especially on various types of *bias* (Dickinson et al. 2010; Sullivan et al. 2014; Kosmala et al. 2016). These issue also could limit its contribution to social decision-making. Therefore, in this column, I intend to construct the relationship between the challenges of citizen science and social decision-making. My contention is that although citizen science poses clear advantages for societal decision-making, its potential is more constrained than expected, which is mainly due to the essential challenges of citizen science. By leveraging these advantages and overcoming these challenges, citizen science holds the potential to significantly contribute to the process of societal decision-making.

Nature of citizen science and conflicts in democracy

Public engagement is one of the essential points of citizen science projects (Hollow et al. 2015; Hecker et al. 2019). These projects can range from simple observational studies to complex experimental designs; thus, they enable the public to contribute to various scientific disciplines (Sullivan et al. 2014; Bonney et al. 2014). When this principle is discussed along with democratic decision-making processes, one could infer that citizen science is regarded as a potent facilitator of endeavors in societal decision-making. However, the extent to which citizens can genuinely engage in the process significantly varies. This limited role presents several implications for social decision-making.

Bias and representativeness

The first challenge is the representativeness of participants in citizen science projects (Fig. 1a). In this aspect, demographic representativeness becomes an issue if citizen science

projects attract participants mainly from specific age groups, socioeconomic backgrounds, or levels of education (Hollow et al. 2015; Osawa 2018). This preference can lead to results that are inapplicable to the broad population. Geographical representativeness becomes a concern if projects attract participants from certain regions but not others, which leads to geographically skewed data (van Strien et al. 2013). For example, urban areas may be overrepresented, whereas rural or less accessible regions may be underrepresented (Dickinson et al. 2010). Temporal representativeness may occur if data collection is concentrated at specific times, such as weekends or holidays, because it may inaccurately represent a phenomenon over time (Callaghan et al. 2019). Accessibility and technology barriers could cause a lack of representativeness if a project requires specific skills or technology, which excludes those without access to these resources (Osawa 2018). Essentially, participants in citizen science project are volunteers; thus, maintaining representativeness for the target community may be difficult.

Accessibility and inclusion

Certain issues emerge even among participants in citizen science projects. Not all individuals have equal access to participate in these projects (Fig. 1b). Individuals without access to necessary technology, education, or other resources may be excluded, which leads, once again, to potential bias and lack of representativeness (Osawa chapterX). The majority of citizen science projects involve the public in data collection and, occasionally, analysis. This contribution undoubtedly extends the reach of scientific research but frequently fails to engage citizens in other stages of research such as design and interpretation. Even in projects that claim to promote participatory science, researchers

predominantly lead the formulation of research questions, methodology, and analysis (Dickinson et al. 2010). This scenario may reduce the ability of a project to reflect the interests, values, and local knowledge of the public (Fig. 1c). The final points of the results and their implications are typically dependent on researchers. This control may undermine the potential of citizen science to genuinely contribute to social decisions that align with the needs and perspectives of a community.

Scientific accomplishments on citizen science projects

Although citizen science projects could avoid or address bias using a circumspect design (Callaghan et al. 2019), preventing the essential bias frequently caused by researchers is difficulty. For this reason, scientific outputs are typically unable to reflect the collective opinion of these projects. When publishing accomplishments, one or a few professional researchers generally lead these projects (Fig. 1c). By maintaining control over study design and interpretation, researchers may inadvertently impose their perspectives and biases, which leads to results that are misaligned with the needs or values of the community. Participants in citizen science projects may hold various expectations or personal stakes in the research outcomes (Osawa chapterX). Thus, the superficial involvement of citizens without genuine empowerment may reduce citizen science to tokenistic participation, which undermines its potential to contribute to democratic decision-making. In reality, however, managing these expectations and ensuring that participants understand the objectives and limitations of these projects can be challenging. In fact, Ecklund et al. (2012) demonstrate that researchers hold the perception that the lack of scientific knowledge among citizens poses difficulty in communicating scientific

discoveries (Ecklund et al. 2012). The advancement of mutual understanding between researchers and citizens (i.e., science communication is perceived as crucial for addressing this issue) and the discussion on this point are, indeed, progressing (Ikkatai Chapter X; Kuehne and Olden 2015; Kondo et al. 2019).

Challenges of citizen science for social decision-making

Although numerous citizen science studies have extensively noted these issues in bias, the primary focus has predominantly been on data bias (Dickinson et al. 2010; Kosmala et al. 2016) in which interpretative bias receives comparatively less discussion. Hence, the question emerges: how should the outputs of citizen science be leveraged in the context of societal decision-making?

Rigorous methodologies, extensive quality control, and in-depth analysis frequently characterize traditional scientific projects for social decision-making, which are typically conducted by professional scientists in the academic, governmental, and industry settings. This process produces high-quality, peer-reviewed knowledge that serves as a solid foundation for informed social decision-making. However, such projects may not always reflect the diversity of community perspectives, may be limited by their specific focus or availability of resources, and may oftentimes be disconnected from on-the-ground reality. Alternatively, citizen science projects are considered to engage the public in scientific investigation, which offers an opportunity for increased community participation and the collection of data at scales or resolutions that may be unfeasible for professional scientists (Bonney et al. 2014; Callaghan et al. 2019). These projects can capture a wide range of perspectives and foster public understanding and engagement in

science. However, as previously discussed, the advantages attributed to citizen science are not always guaranteed. Importantly, when scientists are largely involved in the aggregation of collected data, the scientific achievements that can be garnered may not necessarily be inferior to those of traditional science. Although both traditional and citizen science projects approach discovery and understanding in distinct ways, they are united in their shared pursuit of scientific knowledge and accomplishments. Additionally, they share weak points such as difficulty in reflecting diverse perspectives and limitation in resources. In summary, no essential differences exist between the two forms of science, at least in terms of scientific accomplishment, which could contribute to social decision-making (Fig. 2).

Conversely, citizen science poses certain specific advantages. As widely discussed, this aspect primarily involves the process in which stakeholders that is, the citizens, are directly involved in problem-solving and issue identification. Despite various expectations, the role of science is to provide objective responses. However, the direct involvement of citizens in this process is a challenge for traditional science. In this respect, the application of the outcomes of citizen science to societal decision-making could potentially bear significance, because it realizes an endeavor that was previously unattainable (Fig. 2). Thus, in social decision-making, recognizing the differences between traditional and citizen science, instead of avoiding their dichotomization, would be beneficial.

Social decision-making should be based on a comprehensive understanding that includes the rigorous insights offered by the scientific method and the inclusive perspectives provided by citizens. Notably, these two approaches can be complementary,

and integrating them can lead to more robust and inclusive decision-making processes. From this perspective, citizen science possesses the potential to encompass the critical components of societal decision-making (Fig. 2). However, realizing this potential will likely be a significant challenge for citizen science in the future.

Conclusion and perspective

In conclusion, this column intends to make two assertions. First, no essential difference exists between traditional and citizen science in terms of outcomes; accordingly, no disparity exists in their contribution to societal decision-making. Second, citizen science ensures an advantage in that it permits the participation of citizens in the knowledge acquisition process and possesses the potential to encompass the critical components of societal decision-making. To truly unlock the potential of citizen science in the formation of social decisions, a radical rethinking of participation is required. This process entails going beyond mere data collection to genuinely engaging citizens in all aspects of scientific inquiry that is, from the formulation of a problem to the application of the result as well as its interpretation and publication. Without this shift, citizen science will likely remain an extension of professional scientific practice instead of a transformational force for a more democratic, socially relevant decision-making.

Although citizen science offers a tantalizing prospect for bridging the gap between scientific research and social decision-making, the existing practices and paradigms frequently constrain its true potential. To transform citizen science into a genuine force for democratic, socially relevant decision-making, a concerted effort must be exerted to evolve beyond the current limitations. This aspect requires a reimagining of

participation, a commitment to genuine collaboration, and vigilant monitoring to ensure that citizen science is not merely an extension of professional practice but a transformative approach that genuinely includes and values the voices and contributions of citizens. The future of citizen science lies in embracing these challenges, and, in so doing, realizing its potential to impact not only science but also society as a whole.

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271

272 **Fig. 1.** Inherent biases in citizen science

273

274 **Fig. 2.** Contributions of traditional and citizen science to social decision-making and the

275 potential of citizen science

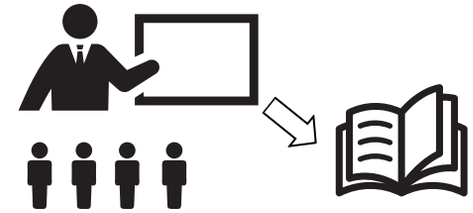
(a) Bias and reprentativeness

gender, age, education, skill, geographic etc...

(b) Accessibility and inclusion

not equal participate, contributions

(c) Scientific accomplishments



professionals tend to lead

Osawa Fig. 2