

Recommendations for designing and implementing citizen science tasks

1. Choose a suitable approach

Citizen science is most suitable for gathering or analysing research data where participants can be motivated to engage without requiring payment or rewards -- i.e., where a task is inherently engaging, supports research for the public good or can be designed in such a manner that it is inherently fun and enjoyable (e.g., Games With A Purpose). Prior to selecting citizen science as an approach, it is important to consider whether the task and research aims align with these goals. If not, consider alternative methods such as paid microtask crowdsourcing or more traditional, lab-based or field studies.

2. Formulate a suitable problem

Consider the task that is to be presented to volunteers. While overarching research questions made be broad, citizen science works best when the questions presented to volunteers are specific and discrete, with limited ambiguity. Think about how the task maps to the activities that volunteers will complete and what resources volunteers will need as well as any specificities and restrictions that will define the task -- for example, will the task require being present in a specific location? If so, the resources, input devices and task steps will be different to a task that can be carried out at home. It's also important to remember that your volunteers may have no experience or knowledge of the concepts that you are presenting to them. Think about how to formulate your task so that prior knowledge isn't required and is widely accessible to beginners.

3. Account for trade-offs

The use of citizen science entails inevitable trade-offs between the quantity of data to be gathered, the speed at which data is to be gathered and the accuracy of the gathered data. Prior to commencing the research process, it is essential to consider and identify which of these factors is to be prioritised and take appropriate steps to safeguard this factor, while taking steps to mitigate threats to the additional trade-off factors. For example, if a project is to emphasise *accuracy and quality of* submissions, the task completion time is likely to increase and this can limit engagement. It is important to then streamline and simplify the task completion process to support faster data gathering or otherwise take steps to encourage engagement to account for these trade-offs.

4. Account for technology

As outlined in the initial guidelines reiterated above, it is important to consider the technology and software that volunteers are likely to use to complete your task. Does the task need to support both mobile and desktop devices or is the task designed to be completed outside of the home? Does the task support multiple browsers? Wherever possible, support diverse technologies to lower any barriers to entry. If participants cannot access your task, then they are unlikely to put in the effort to overcome these barriers and continue contributing. If these barriers are technological, it is also possible that volunteers will not be able to overcome these barriers or will not know how. While it may require a significant commitment of time and resources, it is essential that these issues are resolved upfront and prior to task publication, as participants who encounter these barriers may be unwilling or unable to return to tasks and/or may otherwise remain unaware that these issues have been resolved.

5. Provide Context

Citizen science tasks can often be designed and implemented in such a way that they are trivial and simple for volunteers to complete. This is essential for encouraging accessibility and gathering high quality data, but can obfuscate or

trivialise their research value, with the potential to harm volunteer engagement. Tasks, project resources and educational resources should provide additional context on the value that volunteer contributions pose for the research process.

6. Provide Feedback

While citizen science tasks are generally designed to be easily understood and completed by all participants, not all projects are able to achieve this. Moreover, even where tasks are otherwise easily understood, participants want and need feedback on the accuracy of their responses and the value of their contributions to scientific research. Providing feedback to participants -- either within tasks or through communication features such as forums -- can encourage participant engagement with citizen science.

7. Solicit Feedback

Tasks should not necessarily remain static. The design process involves a number of assumptions and trade-offs which may not align with the expectations of participants. Soliciting feedback from participants is key to ensure that the needs of all stakeholders are met, with the potential for increased task quality and engagement, as well as volunteer engagement.

8. Avoid Ambiguity

While the requirements and processes involved within a task may be clear to task designers, these do not necessarily align with the understanding and motivations of volunteers. To avoid misunderstanding, miscommunication and other issues, avoid ambiguity wherever possible. Support participants through the task process by using discrete, clear questions and limit the need for autonomy and personal judgement. Consider offering multiple choice answers rather than free text responses, for example.

9. Consider Time-scales

While citizen science is an effective way to gather large volumes of data for scientific purposes, volunteer engagement is sporadic, asymmetrical and often brief. It can therefore take a significant amount of time to gather larger datasets. This can be offset by focusing on restrictive, limited-time activities such as BioBlitzes, where volunteers are asked to gather or analyse data over a short period of time. While this approach can be very effective, it is less effective for tasks with more longer-term aims such as public engagement and education. It is essential to consider the implications and long-term aims of the approach to be used and which factors are most important -- is it essential to gather data quickly or in large quantities? Do the research aims warrant longer term engagement and community building or is one off engagement desirable?

10. There's minimal benefit from pre-preparing input data

Scientific research often entails concepts or data with which volunteers may be unfamiliar. While these data must be selected carefully, our findings suggest that there is no significant value to be gained from the pre-formulation of input data, for example grouping data according to perceived difficulty. Instead, presenting tasks at random requires minimal time and resources, with no negative impacts on participant engagement.