Learning Through Citizen Science: Enhancing Opportunities by Design
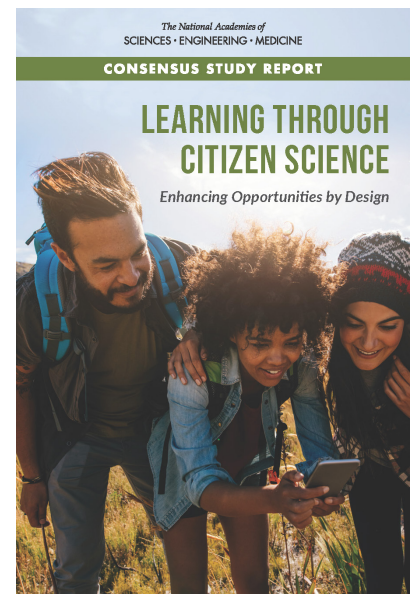
In the last 20 years, citizen science has blossomed as a way to engage a broad range of individuals in doing science. Citizen science projects invite nonscientists to participate in the processes of scientific research, with the goal of advancing and using scientific knowledge. These projects welcome people, including many people without professional training in project-related scientific fields, into a wide range of science-related endeavors, from counting particular species in the environment to monitoring for contaminants in streams to categorizing the structure of galaxies.

Citizen science is uniquely positioned to support participants' learning science, says *Learning Through Citizen Science: Enhancing Opportunities by Design* (2018), a report from the National Academies of Sciences, Engineering, and Medicine. The report identifies ways that citizen science projects can be designed to effectively support learning–for example, by including participants and other stakeholders in the design process, and by using an iterative, collaborative process to develop projects. It urges project designers and stakeholders to design for diversity and to consider issues of equity and power throughout all phases of the project. The report also recommends areas for further research in order to advance understanding and practice of citizen science and science learning.

The report notes that designing for learning has benefits beyond just participant learning: It can enhance overall project goals, like advancing community priorities and enabling scientific discovery.

DESIGNING FOR LEARNING

The report emphasizes the importance of designing citizen science projects intentionally to support participants' learning. If designers are not intentional about learning—in designing the project, by supporting learning during the project, and by investigating learning during and after the project— then it is difficult to know whether and how much participants learned in a given project.

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If one is intentional in design, there are proven strategies that can support designing for learning. One such strategy is to include stakeholders—project leads, scientists, people implementing the project, and especially project participants—in the design process. This engagement ensures that the project's activities will be more attuned to learners' motivations and interests and better able to engage their skills and interests.

Another key strategy is to allow for iteration of the design. Rather than produce a full-fledged product based on a one-time interaction with stakeholders, it is more effective to engage with stakeholders in multiple cycles of feedback and refinement. This kind of process can enhance the effectiveness of promising design features and help weed out ineffective features.

In addition to these overarching design strategies, the report draws upon research on design and practice to offer a number of guidelines that can be used in individual projects:

Know the audience. In designing for learning, defining the audience as explicitly and accurately as possible is a key step. It is important to design messages and programming based on the priorities and preferences that drive people to engage in the program. The challenge and goal is to know and grow an audience of participants/volunteers that is not homogeneous.

Adopt an asset-based perspective. People learn more when learning is connected to their previous experiences and draws on all of their cultural and intellectual capacity. This is harder to do if the project designers think only in terms of filling deficits or gaps in participants' understanding. Instead, practice and theory suggest welcoming the views and conceptions that participants may bring into the project and offering participants the chance to connect their experience in the project to existing knowledge and experience.

Intentionally design for diversity. There is clear and ample evidence that equitable and inclusive design and diverse participation can advance learning for all participants. Research also suggests that if diversity is not explicitly considered, design will default to meeting the needs and expectations of members of dominant or majority groups. Designing for diversity means avoiding deficit framings, which are especially likely to be applied to members of historically underrepresented communities. Projects should be designed to allow and value contributions from and connections for multiple experiences, bodies of knowledge, and epistemological frameworks. Designers should consider issues of power and design to minimize differences in power, and they should avoid making assumptions or choices about what participants will or will not be capable of.

Capitalize on unique learning opportunities associated with citizen science. For example, the centrality of data in citizen science provides a unique opportunity to support participants in developing data knowledge—again, an outcome that does not happen without intention. Facilitating the development of this knowledge can be done through curriculum, explicit instruction, software tools, prompts, or other avenues. Another unique learning opportunity presented by citizen science is the chance to bring people together and build community science literacy—the capacity to harness science knowledge distributed in the community and leverage it for community goals.

Support multiple opportunities for and multiple kinds of participant engagement. The learning of facts and concepts is enhanced through repeated engagement. Frequent, regular participation, even in short activities, such as simple data collection and brief reporting, has better potential for enhancing learning than less regular participation. Repeated engagement can also take place across projects; stronger science outcomes occur when volunteers participate in multiple, varied projects.

Encourage social interaction. Some participants in citizen science projects desire and benefit from engaging in science as a social activity, and many different approaches can support this. Activities as diverse as online forums for participants, data collection in teams, in-person meetings, and having people verify others' classifications all can be designed to provide opportunities for interaction that enhance learning. Even individual data collection projects can be structured to communicate to individual citizen scientists that they are part of a larger endeavor that has social implications.

Build learning supports into the project. Knowing what participants want to learn, and then creating supports for that learning, is important. Those supports can be tools people can use, interactions they can have with one another, and guidance they can get from project leaders. Some high-level strategies for supporting learners include giving participants many examples and frequent feedback; providing participants with opportunities to communicate and apply what they learn; and linking goals for learning to the desired outcomes for the project. On a practical level, supports that can work effectively include tutorials, mentoring new participants by more advanced participants, curriculum, newsletters, personalized communications, peer-to-peer communication, in-person and online training, and interactive multimedia tools such as quizzes.

Evaluate and refine. Good design for learning is an iterative process, and it is necessary to incorporate evaluation, reflection, and revision into the design process. There are relatively few tools for evaluation and iteration that are specific to citizen science or that work across all projects, and so the report urges the citizen science community to borrow, adapt, refine and share. Good evaluation is always answering the question: How do I improve this project?

The report notes that not all citizen science projects are poised to support all kinds of science learning outcomes. Some learning outcomes—increasing motivation and interest, using scientific tools and participating in scientific practices, and learning project-specific disciplinary content—may be easier to achieve in the context of citizen science. Other outcomes—such as improving understanding of explanatory science concepts, supporting the development of a science-related identity, and developing scientific reasoning—may be more challenging and require greater conscious planning and effort by designers.

RECOMMENDATIONS FOR PRACTICE AND RESEARCH

The report offers several recommendations intended for all designers of citizen science projects, with the understanding that designers include a wide and representative range of stakeholders and that effective design extends well into implementation.

Recommendation 1: Given the potential of citizen science to engage traditionally underrepresented and underserved individuals and communities, the committee recommends that designers, researchers, participants, and other stakeholders in citizen science project design and implementation carefully consider and address issues of equity and power throughout all phases of project design and implementation.

Recommendation 2: In order to maximize learning outcomes through participation in citizen science, the committee recommends that citizen science projects leverage partnerships among scientists, education researchers, and other individuals with expertise in education and designing for learning.

Recommendation 3: In order to advance learning, project designers and practitioners should intentionally design for learning by defining intended learning outcomes, identifying a participant audience, integrating learning outcomes into project goals, and using evidence-based strategies to reach those outcomes.

Recommendation 4: In designing or adapting projects to support learning, designers should use proven practices of design, including iteration and stakeholder engagement in design.

As an emerging field, citizen science has opportunities to grow, to contribute to what we know about how people learn science, and to broaden participation in science. The report offers recommendations for research that can advance the field and inform the design of future citizen science projects.

Recommendation 5: The educational research community should perform regular analyses of the available evidence on learning in citizen science in order to identify and disseminate effective strategies.

Recommendation 6: Relevant researchers should perform longitudinal studies of participation and changes in individuals' and communities' scientific knowledge, skills, attitudes, and behaviors, both within individual projects and across projects.

COMMITTEE ON DESIGNING CITIZEN SCIENCE TO SUPPORT SCIENCE LEARNING

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