eeWORKS

From Anecdotes to Evidence: Demonstrating the Power of Environmental Education

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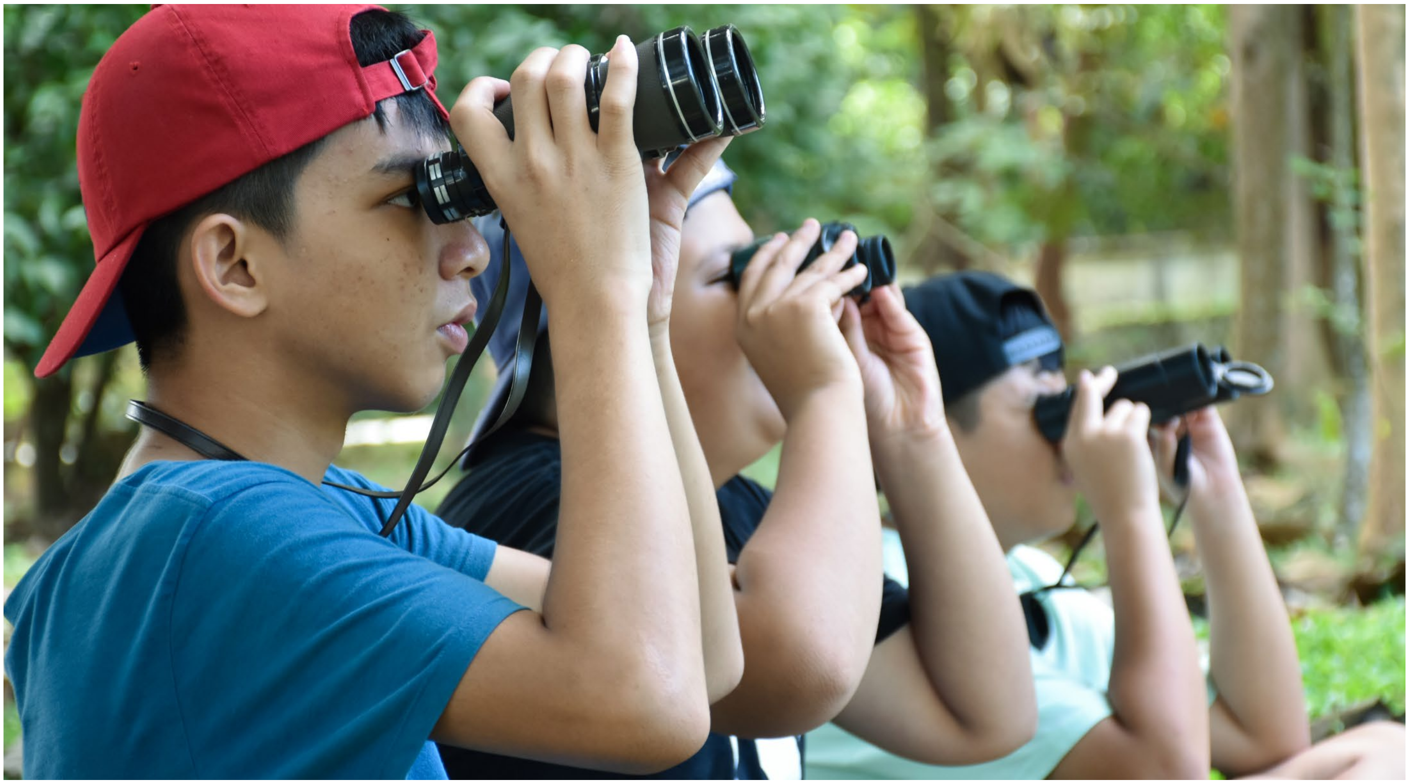
Community and Citizen Science Programs Support Environmental Education Outcomes



A research team at the University of California, Davis analyzed 100 articles in the peer-reviewed literature that evaluated community and citizen science (CCS) programs and determined that these programs achieve a variety of environmental education outcomes.[1] After selecting papers that met their criteria from a pool of 1639, the team read and coded each paper for participant impacts. These outcomes include gains in knowledge, positive environmental attitudes, and skills in data analysis and problem solving. Some of the programs also increased social connectedness by engaging communities in discussions of local problems. Other programs increased trust in science, enabled people to see themselves as people who use science to solve problems, and increased their environmental and stewardship behaviors. For more details on the key findings, please see *Executive Summary and Key Findings.*

The team explored the literature across a spectrum of programs anchored on one end by traditional scientist-led public data collection programs that may have large numbers of participants, such as the Christmas Bird Count,[2] or a few highly trained participants, such as LakeWatch.[3] While the majority of programs used adult volunteers, some were designed for classrooms (primarily middle and high schools), such as GLOBE. At the other end of the spectrum were co-created projects that engage community members in defining the problem and research question as well as ways to engage people in collecting, analyzing, and reporting the data. Some of these community science programs involve focus groups and mapping projects that engage people in providing information or collecting it from their neighbors in an effort to build momentum to create social change.

Because community and citizen science approaches have often been considered strategies of science education, participant learning is typically evaluated against science education goals, such as gaining science content knowledge, science inquiry skills, knowledge of the nature of science, trust in science, and science interest. Environmental education programs may wish to achieve these science education goals, but also tend to emphasize pro-environmental attitudes, problem-solving skills, self and collective efficacy, and pro-environmental behavior change. The review found that community and citizen science programs can achieve all of these outcomes, with some assessed more often than others (see Fig 1).

A variety of strategies were designed into these community and citizen science programs to achieve these outcomes. For educators interested in using community or citizen science strategies, the following recommendations may assist them in adopting or creating programs that can achieve the myriad of important outcomes noted above. These strategies, effective both individually and in combination, aim to deepen scientific knowledge and contribute to positive environmental outcomes through first-hand inquiry, data collection, analysis, and reporting. Educational strategies that incorporate fieldwork, data analysis, and digital tools can provide the foundation of an effective learning experience. The following strategies offer educators a range of tools to make community and citizen science strategies engaging and impactful:

Figure 1: Learning Outcomes from Citizen Science Programs found in Ballard et al. (2024) review:

- **Environmental science content knowledge** (56 papers)
- **Science inquiry skills** (32 papers)
- **Community-level outcomes** (30 papers) **environmental behavior and stewardship** (29 papers)
- **Positive attitudes toward science and environment** (16 papers)
- **Self-efficacy with science or environment** (11 papers)
- **Place values and connection to nature** (9 papers)
- **Interest in science or environment** (6 papers)
- **Identity and agency with science or environment** (4 papers)

STRATEGY #1

Making sense of data collection.

Collecting data via online and field-based observations in rural and urban environments is one defining feature of CCS. Effective programs help learners understand what they are doing and why, providing training in the skills needed to collect valid and reliable data and becoming familiar with the scientific process. Participants learn about the organism or problem they are addressing and the nature of science.

- Participants of a citizen science program in Wisconsin and Colorado learned to identify and monitor invasive species over a two-day training program. After the training, they demonstrated an increase in their understanding of context-specific scientific literacy and reasoning.[4]
- As part of the WideNoise program, participants used a mobile app on their smartphones to measure and estimate noise levels in several countries in Europe. By comparing their estimates with actual measurements, participants improved their ability to discern different environmental noise levels. This hands-on experience with both quantitative and subjective data (such as opinions and noise perceptions) also enhanced their skills in data collection and analysis.[5]
- Researchers and policymakers in St. Albans, Vermont, created a program to involve local community members in the development of a watershed model to identify effective phosphorus control options to protect Lake Champlain, which receives excess nutrient runoff. Stakeholders, including local decision makers and community groups, collected water samples, discussed model results, and developed solutions. The project facilitated improved understanding of local environmental issues, enhanced collaborative decision-making, and identified cost-effective solutions for managing phosphorus loads, ultimately influencing watershed management decisions.[6]

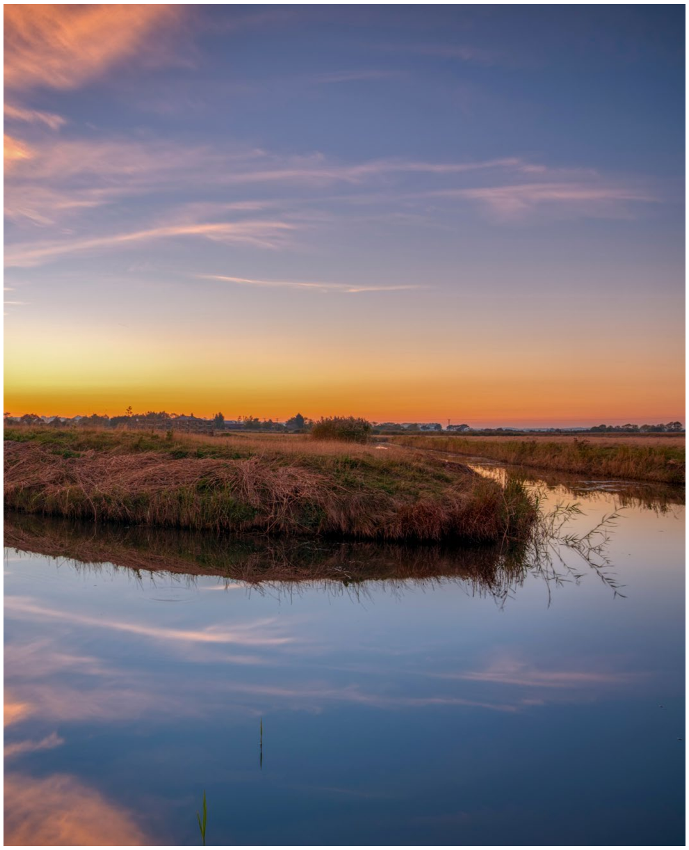
STRATEGY #2

Working with the data and sharing findings. While some effective programs only involve participants in collecting data, learners tend to gain important outcomes from analyzing, interpreting, and reporting the data to others. The activity of this additional work, and especially of sharing the findings, involves reflection and helps participants process the information. Consider extensions to the project by facilitating actions that use the data. The Next Generation Science Standards[7] encourage educators to engage students not only in planning and collecting data, but also in data analysis, interpretation, and reporting.

- Members of the Lune River Trust in northwest England collaborated with academic researchers to map problem areas in their watershed and discuss what was already known before settling on the topic of animal waste pollution to explore together. Reflecting on the data enabled one participant to generate a novel use for their work—identifying farms that were vulnerable to contributing to water pollution. Local involvement and expertise contributed to more effective watershed management strategies.[8]

- Elementary teachers in Australia used Operation Magpie to involve students in collecting data about these common birds. Students recorded location and behavior of magpies in gardens and schoolyards, photographed bird nests, exchanged stories about bird sightings, and shared their observation data with urban ecologists. The teachers used the experience to develop students' skills through writing poetry and descriptive reflections about observations and increased students' interest in their local environment.[9]

- A participatory resource monitoring program in Yunnan, China, engaged adult members of a village in monitoring local forests in and around nature reserves to improve involvement in forest conservation practices and policies. Local teams monitored wildlife abundance, crop damage, and land use through observation, interviews, and market surveys. After one year of data collection, the villagers and staff reflected on their data and recommended management decisions to address the problems they observed. Participants reported they better understood their environment and used that information to better manage resources; communication and trust between community members and management staff also improved.[10]



STRATEGY #3

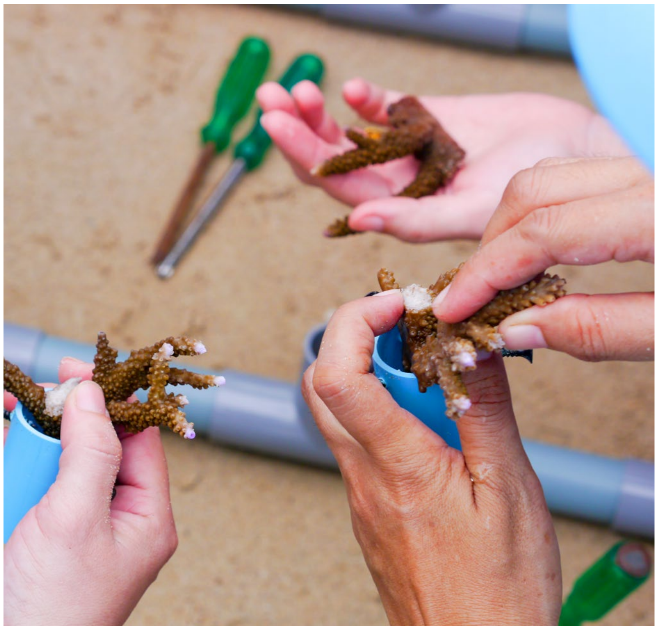
Emphasizing the local place, particularly in mapping projects, as people learn how to protect and steward their own resources.

- Wildfires in Australia are particularly dangerous, with the capacity for native trees such as eucalyptus to burst into an inferno. A participatory mapping workshop in the state of Tasmania collected data from participants and engaged residents in exchanging information on wildfire risk by adding information to collaborative digital maps. Researchers reported that participants began to recognize they had important information to share with others and the value of increased social connectedness.[11]
- Two programs – Virginia Master Naturalist and California Naturalist Programs – involved participants in nature observation and data collection using iNaturalist and other tools during their training in local natural history. As part of a 40- to 50-hour training program, participants were introduced to several citizen science programs and encouraged to contribute observations. Participants deepened their understanding of local environments and biodiversity, while also fostering a connection with nature and encouraging community involvement in conservation efforts.[12]
- In South Florida, USA, recreational SCUBA divers and snorkelers collected samples of threatened corals as part of the Rescue a Reef (RAR) program. They worked with scientists to grow these collected pieces of staghorn corals in a nursery and then transplanted them to favorable environments and monitored the reef recovery. The program not only contributed to reef restoration, but also enhanced participants' understanding of coral reef ecology and the importance of their activities.[13]

STRATEGY #4

Connecting to the local community.
Regardless of the group of learners (students, youth, or adults), programs may benefit from connections to the local people in their communities. Consider using local experts as resources, reporting findings to local committees, and using local media to share the process and outcomes with others.

- Educators in several metropolitan areas in the eastern United States used the Garden Mosaics program developed by Cornell University to engage youth in an urban community garden exploration project. Unlike other programs where youth create gardens, these participants conducted garden mapping, neighborhood exploration, and recorded gardeners' stories through interviews. They gained insights into diverse cultural gardening practices, realized the value of local knowledge, and made new community connections.[14]
- Fogones de Fauna was a wildlife monitoring project in Uruguay, which aimed to foster deep connections between community members and local ecology. It involved children, youth, and adults in collecting and analyzing data; sharing local ecological knowledge; and deliberating about the results. The project increased local collective knowledge of biodiversity, fostered community engagement and trust, and empowered residents in environmental decision-making through theatrical performances, and activities with maps as well as audiovisuals.[15]



STRATEGY #5

Investigating social-ecological aspects of issues.

There are human implications to all natural science questions, and environmental aspects to all social issues that face communities in the 21st century. Justice and equity concerns are also paramount. Data from nature observations can be part of understanding a larger picture of socio-ecological issues. Data collected through surveys and interviews about community members' perspectives or experiences can be equally useful in resolving local issues.

- In Mohawk, New York, community members, specifically a midwife and mothers, worked with local university scientists to design and implement a PCB contamination assessment. This project grew to include a comprehensive health study with cognitive assessments and nutritional surveys, conducted by trained community fieldworkers.[16]
- The GET City Program in Michigan is a science program that helped youth investigate the feasibility of a new power plant. Young people sought insights from energy experts, surveyed community opinions, explored alternative energy sites, conducted renewable energy experiments, and organized a community forum to present their findings. The program helped foster meaningful dialogue among key stakeholders and engaged youth in authentic scientific inquiry.[17]

STRATEGY #6

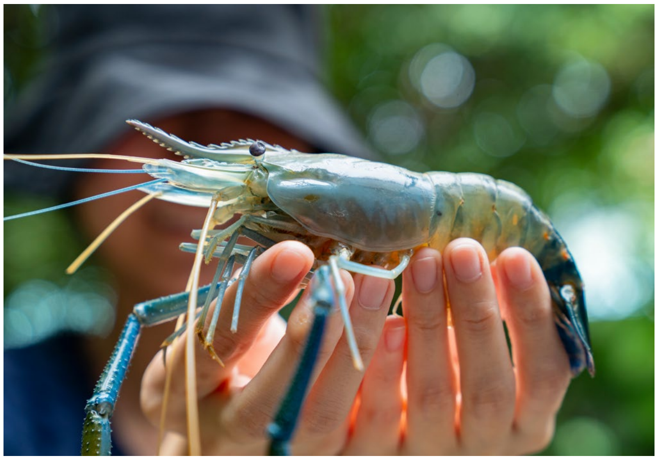
Exploring with digital technology.

Recent advances in technology have made it easier to submit data via smartphones, access databases on the internet, plug datapoints into mapping software, and analyze data. Digital and online technologies may increase interest in topics, increase learners' skills, and broaden impacts of a program.

- FracTracker is a participatory geographic information system (GIS) that engaged community members, researchers, and environmental advocates in mapping, storing, and sharing data on their concerns about fracking. While users accessed the system anywhere in the U.S., most survey respondents for this study were from Pennsylvania and New York states. The platform allowed participants to visualize and comprehend the environmental and health impacts of natural gas development, which helped users contribute to informed community response and policy advocacy. Users of FracTracker referred to these data to inform discussions with regulatory officials and write letters to state representatives and regulatory officials.[18]
- A summer enrichment program explored environmental justice and environmental health through a community-university partnership. College students from the health sciences program learned about the research process and how to collect data, then walked through two communities in North Charleston, South Carolina, to map coordinates of various assets and hazards with GPS units. Community members enhanced these maps with additional features of their neighborhoods. Students analyzed the facilities, pollution levels, and census data to explore disparities and communicated their results to scientists, community advocates, and residents in the city.[19]
- A growing number of online citizen science programs involve volunteers in computing, transcribing and annotating manuscripts, or participatory sensing. Participants analyze existing data, or collect new data using such technologies as GPS, digital compass, mobile networks, as well as audio-, photo, and videorecording. These citizen cyberscience volunteers not only learn about the research topic and develop scientific literacy, they also demonstrate increased motivation to engage with science through social interactions, by building learning communities, and through developing presentations of their research.[20]

Conclusion

Many of the strategies described here can be used in environmental education programs and have been demonstrated to support environmental education and science education outcomes. To learn more about developing effective environmental education programs, please see the *Guidelines for Excellence in Environmental Education.* For more information about program evaluation, please visit NAAEE's online database of evaluation strategies, the research and evaluation learning module in eeLEARN, and the environmental education workbook for practitioners.



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