FRAMEWORK

Fostering Environmental Science Agency

In Youth-focused Community and Citizen Science

Photo courtesy of NHMLA

When do experiences with science lead young people to create change in their lives and communities?

As educators and researchers, we are focused on joining young people in the work of learning, doing, and using science to improve the world we share. This means thinking about young people as community leaders and people who do science. We also need to understand and strengthen the connection between "learning science" and "making change in the world.[1]" The concept of *environmental science agency* (ESA) helps us do this.

What is ESA and Why Does it Matter?

Environmental science agency (ESA) is the ability to use experiences in environmental science to make positive changes in one's life, landscape and community[2]. The concept of agency in this case emphasizes youth action and improvisation; that is, the ability to act on the world in personally meaningful ways[1]. Promoting ESA includes *learning science while doing science*, and can be a way to foster environmental stewardship, civic participation and meaningful science learning.

ESA is adapted from Basu and Barton's concept of *critical science agency*[3], which points to a need for new paths into, and through, science, especially for young people from historically marginalized communities. Focusing on ESA can help educators bridge inequities and encourage people to carve out places in science for personal and community interests.

Research in science learning has shown a need to consider the identities and cultural backgrounds and experiences that learners bring with them[4], and to promote science learning that emphasizes *doing*, and not just *knowing*, science[5]. Studies have also shown that working within and contributing to communities[6] also allows young people to learn norms, habits of mind, and dispositions that make science a powerful tool for understanding their world.

Lastly, ESA incorporates theories of youth agency that emphasize that gaining power and agency in one's life, and in our communities, requires both individual and collective action. Embodying this idea, young people participating in CCS projects that tackle environmental science questions locally and globally take responsibility for small parts of larger scientific efforts.

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Youth-focused community and citizen science (YCCS) involves young people directly in the scientific production of knowledge. In YCCS, young people contribute to professional research, influence management and policy, and impact environmental conservation in their communities.

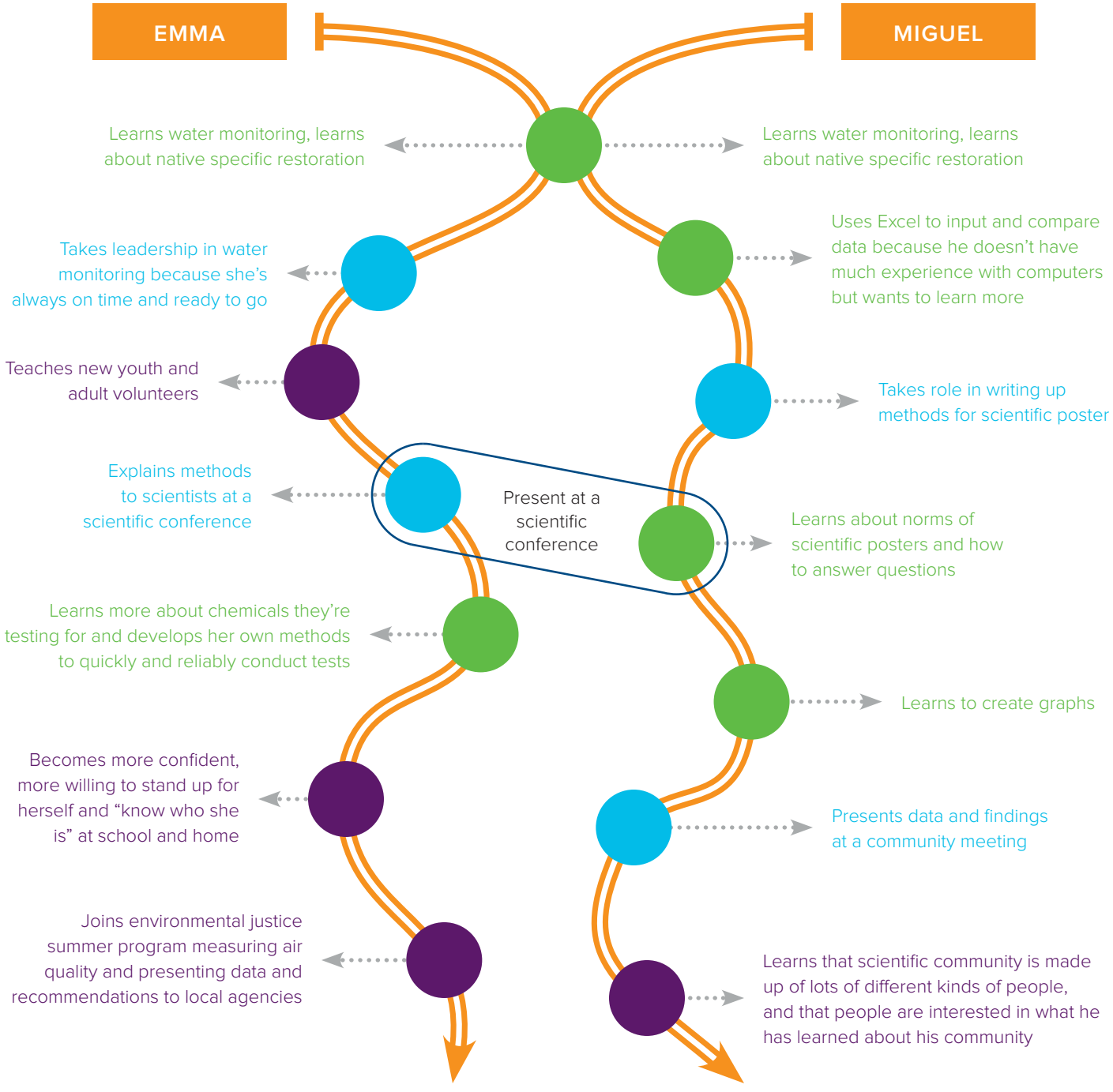
What does it look like when youth develop Environmental Science Agency?

To observe the development of ESA we look for evidence of three core elements, which build on each other but can occur in any order:

- Deepening understanding of environmental science content and practice.
- Identifying an area of one's own expertise in environmental science.
- Using experiences in community and citizen science as a foundation for change.

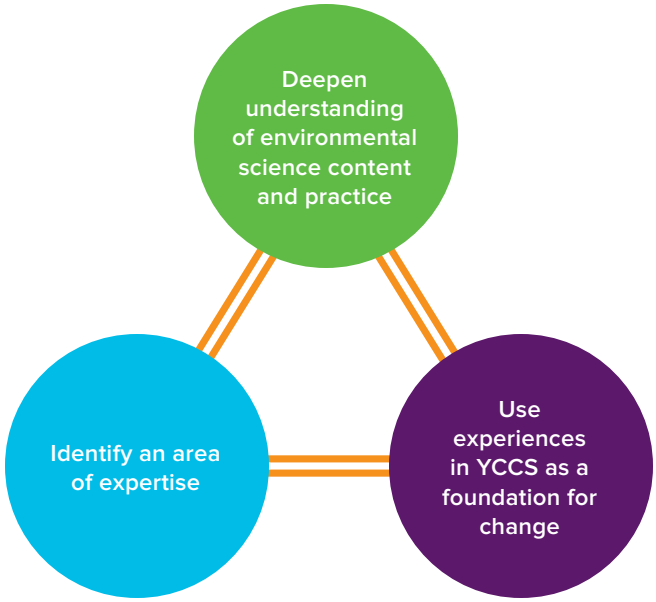
In our case studies, we saw youth learning the skills, values and practices of environmental science. We also saw young people take up those practices to develop unique or personalized roles within the scientific work. In the third component, we saw youth build on those project experiences to create change in their own lives or the local community and environment in which they lived.

Pathways of ESA development for different young people can look really different, even within the same project. Here are the pathways of Emma and Miguel, both participating in a water quality monitoring and restoration project.



Building Blocks of ESA

To observe the development of ESA in youth, educators can look for three things:



1. Deepening understanding of environmental science content and practice.

This includes learning to use technical tools, such as calipers, water testing kits, excel spreadsheets; coming to better understand natural phenomena and systems, such as parasites on crabs, effects of dumping and invasive species on water quality; or learning scientific practices, such as how to ask a question, how to write for a scientific audience. For example, youth might be encouraged to think about the limitations and tradeoffs of a dataset or to learn norms for scientific writing and presentation. Or they might learn about ways in which policies and human behaviors impact natural features at a large scale (e.g., global warming), or at a small scale (e.g., the influence of homelessness and sewage breakages on streams and lakes).

When equipped with the relevant content knowledge and inquiry skills, youth are able to notice environmental problems *and* identify solutions. For example, we observed fourth graders involved in a bird monitoring program engage in scientific inquiry, learn about birds and plants native to the area, and determine how to rehabilitate local habitats for birds.

2. Identifying an area of their own expertise in environmental science.

Youth find specialized roles within a YCCS project and become an expert or resource to the group for that topic. This process is vital for youth to build a scientific identity, gain a sense of contribution, and come to see how science can be powerful for one's own purposes. We observed a range of roles that young people take up, from those focused narrowly on the scientific work being done, to more social roles, such as teaching new students how to collect data, or giving presentations to community members.

Young people may gravitate toward interest areas on their own, or educators might point them toward a particular project need. Some projects design for a variety of participant roles, allowing young people to identify areas of interest and move across roles as they gain experience. In a high school class doing coastal monitoring, for example, several youth talked about "stepping up" to lead the writing of scientific blogs. Another student described identifying as a "researcher" and talked about how this shifted her attitude about science.

3. Using experiences in community and citizen science (CCS) as a foundation for change.

Young people build from the identities, knowledge, activities, or networks that they develop over the course of YCCS participation to take action or make a change.

We observed youth agency manifested in many small ways, such as an intern carrying new scientific identities and activities into his school setting; a student building greater confidence to speak up for her ideas; or a youth leader gaining a new perspective on how to address community issues. We also saw bigger, more concrete ways that young people created change, such as advocating for policy changes before city council members, bringing environmental concerns back to family members or peers, or seeking out opportunities to expand research and participation in scientific work.

Considerations for Fostering ESA

ESA connects short-term activities to long-term learning

When developing ESA, youth move from practices that most students in a project might learn (like how to use a transect tape measure), to focusing on more specialized roles that reflect individual interests. Rather than everyone having the same learning experiences, we need to encourage the highly varied ways that science and YCCS experiences can become meaningful to young people. This trajectory can help educators and project designers think about how short experiences and concrete practices of science might connect to longer term learning processes.

ESA develops with feedback loops and multiple entry points

For example, learning and developing a knack for using calipers and water testing kits led one student to take responsibility for data collection and analysis in her team or class. As a result, she learned more about principles of data quality and their importance for being able to make credible claims. Extending her work in the project, she then came to teach peers and adult volunteers how to collect and assess water samples, gaining leadership skills that her grandmother saw her put to use at home and in school. The YCCS project provided multiple ways for her to participate in the science process and decide what role she found most meaningful.

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Knowing and doing are intertwined

Developing ESA isn't a one-way, linear process. Each step is *iterative*—learning activities overlap with and strengthen prior learning, experiences, and interests—and *generative*—youth slowly expand and deepen what they know, in order to develop agency to act in more powerful ways within projects and across other settings. Like the learning theories we've cited above, we emphasize that learning and acting—knowing and doing[3]—are intertwined: neither can advance without the other.

Recommendations from our Research

Our research draws from 10 cases of YCCS in classrooms, summer programs, internships, and service projects for youth from 8-18 years old. These cases provided a close-up look at the kinds of interaction, learning and work that is actually going on. We saw students gaining new perspectives on the places they saw everyday, teenagers stepping up to become leaders in the program and begin to advocate for environmental resources in their communities, interns carrying new practices and new identities into other places they were involved. We did not see this happen with every young person and so we worked to identify pathways that were important across different kinds of projects.

Key Practices for Youth

We have identified three practices that were common among many of the youth participants, and which formed pathways of ESA development. These key practices provided focal points around which youth could both build understanding of scientific practice, and increase a sense of contribution to YCCS work. To learn a lot more details about these key practices, ways they have been implemented in YCCS projects, and implications for project design and facilitation, including **tips for implementation**, visit yccs.ucdavis.edu/key-practices.

Key Practices for Educators

We have also identified effective practices that educators can use to deepen learning and foster ESA during the course of YCCS activities, regardless of the particular project or program, in any setting including classrooms, gardens, summer programs, or after school settings.

Key Youth Practices

Take ownership of data quality
Young people take responsibility for ensuring high quality CCS data collection and analysis.

Share findings with outside audiences
Youth share findings from their work with audiences such as administrators, scientists, and community stakeholders.

Engage with complex social ecological systems
Youth think about the interactions between humans and nature and consider the role they and their communities play.

Key Educator Practices

Position youth as people who do science
Help youth take on meaningful roles during the CCS investigation by engaging them in the discussions, deliberations and meaning-making practices of science.

Attend to the unexpected
Pay attention to interesting surprises that come from the natural world or youth and incorporate them into instruction.

Frame the work globally and locally
Frame the work simultaneously as part of broader global scientific endeavors as well as locally relevant issues around the study site or community.

Case Studies

Our case studies document project structure, products and scientific knowledge that youth generated, and the ways that ESA components were manifested by youth:

- Aerial Mapping: Elective Science Course
- Bird Monitoring: 4th Grade Class
- Sand Crab Monitoring: Museum Internship
- School Garden: Elementary School Classroom
- Urban Creek: Teen Summer Program
- Milkweed Monitoring: Summer Internship for High Schoolers
- Bioblitz: One-day Community Events
- Tracking Sage Grouse: In The Field and Online

Read more at yccs.ucdavis.edu/case-study.

[1] Holland, D., Lachicotte Jr, W., Skinner, D., & Cain, C. (1998). *Identity and Agency in Cultural Worlds*. Cambridge, MA: Harvard University Press.

[2] Ballard, H.L., Dixon, C.G., Harris, E.M. (2017). Youth-focused citizen science: examining the role of environmental science learning and agency for conservation. *Biological Conservation*. 208: 65-75.

[3] Basu, S. J., Barton, A. C., Clairmont, N., & Locke, D. (2009). Developing a framework for critical science agency through case study in a conceptual physics context. *Cultural Studies of Science Education*, 4(2), 345-371.

[4] Gutiérrez, Kris D., and Barbara Rogoff. (2003). "Cultural ways of learning: Individual traits or repertoires of practice." *Educational Researcher*. 32(5): 19-25.

[5] NGSS Lead States. (2013). *Next Generation Science Standards: For States, By States*. Washington, DC: The National Academies Press.

[6] Rogoff, Barbara. (2014). "Learning by observing and pitching in to family and community endeavors: An orientation." *Human Development*. 57(2-3): 69-81.

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ABOUT THE YCCS PROJECT: Youth-focused Community and Citizen Science (YCCS) involves young people directly in the scientific production of knowledge. Beginning in 2013, a team based at the UC Davis School of Education has been studying YCCS projects in Northern California, and convening project designers, teachers, scientists and others involved in YCCS to generate and share knowledge of when and how YCCS works best. The YCCS project is part of the UC Davis Center for Community and Citizen Science. To learn more, please visit education.ucdavis.edu/ccs.