CITIZEN SCIENCE TOOLKIT

Teaching science through citizen science

CALIFORNIA ACADEMY OF SCIENCES

In this toolkit

This toolkit is designed to help educators, like yourself, integrate citizen science projects into classroom curricula or afterschool programming. It contains resources—including lessons, readings, and worksheets—to help you communicate the value of citizen science to your students and help them cultivate a sense of empowerment and impact when performing science investigations.

You can use this toolkit in the order outlined or adapt it to meet your needs. Similarly, the activities and projects are designed for you to use as-is or to modify to fit the context of your classrooms.

LEARN

ACT

EXTEND

What is Citizen Science?

Citizen science is a process by which anyone can take an active role in scientific discovery. Harnessing a collective curiosity and employing common technology, citizen scientists work with professional researchers to learn about our world more quickly and comprehensively than ever before. Projects can take many forms: counting backyard birds to assess climate change, searching satellite images for new galaxies, and playing video games to fight diseases are just a few ways that citizen scientists directly contribute to cutting-edge research spearheaded by universities, museums, and other major institutions.

Some citizen science projects arise when a research team makes a public call for assistance to help answer a question. For example, in July 2007, astronomers faced the task of classifying one million galaxies that had been imaged by the Sloan Digital Sky Survey. They realized that even if all the astronomers in the world did nothing but classify galaxies for the rest of their lives it would still take 200 years to complete the work, so they created the Galaxy Zoo project and invited the public to help. Within 24 hours, they were receiving 70,000 classifications per hour; by the end of the first year, more than 50 million classifications were made by 150,000 people. That meant each galaxy was seen by many different participants, which helped ensure the classifications were reliable, accurate, and as trustworthy as those made by professional astronomers. Citizen scientists not only correctly identified the shapes and features of the galaxies, but also discovered brand-new astronomical objects and brought to light a whole new class of galaxy. In 2015 alone, citizen scientists contributed over 4.75 million classifications on 200,000 different images of galaxies. These remarkable achievements could not have been made without this tremendous response from the public.

Collaborative efforts like these offer communally beneficial experiences for all involved. The scope of scientists' research is often limited by time, budget, and people power. With the help of citizen scientists, research can be done more quickly, information can be shared more readily, and our knowledge can expand exponentially. For student participants, the immersive experience of citizen science makes learning fun and offers a clear integration of science understanding with real-world application. Working together, citizen scientists and professional researchers help create a community of more knowledgeable and better-informed community members who can respond quickly and effectively to issues that arise in our rapidly-changing world.

Some citizen science achievements

- The nine-spotted ladybug, *Coccinella novemnotata*, is the state insect of New York, but had not been seen since 1982. The species was thought to be extinct until a citizen scientist participating in the Lost Ladybug Project rediscovered it in 2011 on a sunflower at an organic farm in Long Island.
- Scientists had been struggling to model an enzyme critical to AIDS research for ten years. Once they brought their problem to the online protein-folding game called Foldit, players found the solution in only three weeks.
- A project called Digital Fishers invites citizen scientists to help classify organisms seen in videos taken of the seafloor off Vancouver Island. A teenager in Ukraine was watching a clip of a hagfish swimming along, when a whiskery nose suddenly came into frame and slurped it up. His curiosity piqued, the student contacted researchers to ask what he had seen. It turned out to be an elephant seal, but scientists had never before known that they dive so deep or that they eat hagfish!

The Value of Citizen Science in the Classroom

Citizen science fosters scientific literacy by engaging students in meaningful science research that addresses real world issues and leads to scientific advancement. Through direct participation in science inquiry and exploration, students develop critical mindsets about the nature of scientific discovery.

Anyone, anywhere can be a scientist.
Citizen science democratizes the scientific research process by lowering the barriers to entry and raising the impact of civic engagement. Using simple tools and everyday technologies, novices with little expertise living anywhere in the world can make and share critical contributions to authentic investigations. The citizen science experience makes science more accessible, expands the view of science beyond a laboratory, and empowers students to identify as active agents of scientific discovery. Through technology, the impact of participation moves beyond a single classroom or school to a greater civic and scientific community.

There remain unanswered questions in science.
Scientists have described less than 15% of all the species believed to exist on Earth and we know more about the surface of Mars than we do about our own ocean floor. Though science has made tremendous progress in the effort to understand the diversity of life and how things work, there is still much to learn, and every thrilling discovery raises equally exhilarating questions. Citizen science gives participants insight and exposure to the idea that there remain mysteries to solve, that the internet does not hold all the answers, and that science is a dynamic and ever-changing process of pursuing curiosity.

Science serves society. Society needs a scientifically literate populace.
Science is a framework and method for the exploration and understanding of how the world works. We rely on scientific knowledge to help identify and solve societal problems. For example, an understanding of decomposition and energy cycles can inform decisions about waste management, and considering chemical interactions can lead to policies that protect our clean water supply. Through citizen science, students strengthen their scientific literacy and use their skills to assess and address real issues.

Curiosity and fun drive scientific research.
All that we know about the nature of the universe is a result of human curiosity and agency. Over the course of history, people have posed questions and pursued investigations. Students who participate in citizen science recognize that new scientific discoveries can be made by anyone and that systematic follow-through can yield satisfying results. For many, the process of exploration and discovery is delightful, enthralling, and a tremendous amount of fun. Whether they choose to make science their career or engage in it as a hobby, citizen science provides everyone with the chance to learn about the world while contributing to greater good.

Supporting the Standards

By framing citizen science in the context of the scientific inquiry process, projects can support the Next Generation Science Standards (NGSS)'s Scientific Practices and Crosscutting Concepts, as well as some Common Core State Standards (CCSS). For a full explanation, see the Citizen Science & the Standards section.

Citizen Science Skills

Citizen science projects emphasize engagement in the process of inquiry rather than rote memorization of facts-based content. Students will carry these foundational skills with them in future pursuits, scientific or otherwise.

Observing

All scientific progress begins with observation. Citizen science offers students the chance to recognize the importance of looking closely, slowing down to notice details, identifying patterns, and making connections. Because many citizen science projects rely on the ability to discern differences among similar-looking objects or organisms, students naturally train their eyes to recognize important features. Whether they identify ladybugs in the park or record different types of clouds, citizen scientists use their observational skills to amass critical data points that inform authentic research.

Questioning

As they make observations and gather data, students can be guided to think critically about their findings and begin to ask questions. For example, in searching for the sixteen focal species of the Celebrate Urban Birds project, students may wonder why they find an abundance of pigeons in their schoolyard but very few pelicans. They might develop a hypothesis and design a testable question to determine reasons for this. As always, additional observations will answer some questions, while raising new ones. Through citizen science, students will learn firsthand that science is not a linear process, and that questions and hypotheses may arise and be revised over and over again.

Planning

To successfully participate in a citizen science project, the class will need a realistic, comprehensive plan. Will students work individually or in groups? How will they collect and record their data? Putting the power of decision-making into the hands of the students will allow them to take ownership of their experience and feel empowered to troubleshoot obstacles.

Citizen science projects also provide the opportunity to explore different data collection methods by considering what information is necessary to answer the question at hand. For example, how will they determine how much data to collect? What kind of information is most relevant? This is a chance to discuss how students can make sure their data are accurate, and what evidence would allow them to defend their findings.

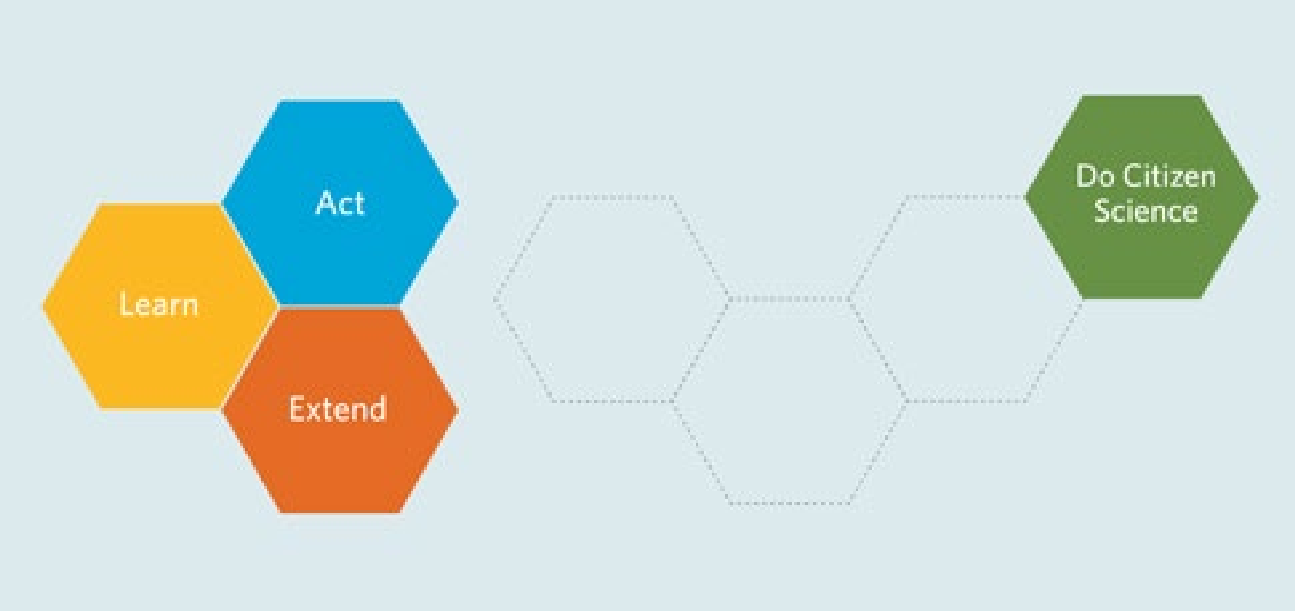
Analyzing

Through citizen science, students can learn how to analyze, interpret, and critically extract meaning from information. A strong command of how to examine data will allow students to support or challenge hypotheses, defend scientific conclusions, and develop an understanding of how science can inform everyday choices. Whether students collect their own data or mine data contributed by others, they will have the opportunity to explore multiple perspectives, employ logical reasoning, and build understanding from evidence.

Communicating

The power of scientific discovery rests on its ability to impact scientific understanding, public policy, and social culture. To garner support and foster change, scientists must communicate the implications of their findings in a clear and effective manner. Once students analyze and interpret their data, they can begin to construct scientific arguments and share them with classmates, family members, community members, and even local policy-makers.

About the Citizen Science Workbook



The following section is a workbook designed to walk you through the process of planning and carrying out a citizen science project with your students.

Meaningfully integrating citizen science into the classroom requires guiding students through the full cycle of scientific inquiry. Throughout the workbook, you will develop ways to explain citizen science, select and carry out a project, and extend the experience. You will also find tips and tools to assess progress and understanding. Successful assessments highlight not only what the students have learned, but let them identify topic areas to focus on for better understanding or further inquiry.

There is no one approach that will work with every class, so use the tools and activities outlined in whatever way best suits your needs.

How to use the interactive workbook

1. Print or download a copy of this PDF.
2. Open it using Adobe Acrobat Reader (or a similar program that allows you to fill out PDFs).
3. Add your thoughts and notes in text boxes or create your own comment boxes.
4. Save.

ACT

Get Started

Integrating citizen science into the formal classroom presents both an opportunity and a challenge. Outside of school, citizen science is an interest-driven experience, fueled by self-motivation and passion. Citizen scientists channel their love of learning into active civic engagement by choosing to spend their free time collecting dead bees or documenting the biodiversity of intertidal reefs to better understand and protect our planet. As a mandatory assignment within an academic curriculum, citizen science may not hold the same intrinsic allure for middle and high school students. Providing context will help your students understand the relevance of citizen science and recognize the value of their role.

Citizen science is real, practical, and authentic work: it exists to answer genuine questions and overcome true limitations. In these ways and others, citizen science has the potential to radically transform science education. Without this context, a citizen science project may seem no different from the typical school experience.

In this section

- Set the stage
- Explore preconceived notions of "science" and "scientists"
- Why do scientists want us to do their work?
- Assessment Check-in #1

ACT | **workbook**

Get Started

Set the stage

Students may need to be guided through a process of framing to understand the significance of the scientific question they are answering and the relevance it holds in their own lives.

Take a minute to consider what you want students to take away from the experience:

- What is citizen science?
- Why is it important?
- What might be fun about it?
- What might be challenging and why is it worth the struggle?
-
-
-
-
-

Some activities to get students started include:

- Convince Me - Persuade someone to take action on an issue you care about.
- Produce a Citizen Science Video - Understand and articulate what citizen science is and why it is important.

Get Started

Explore preconceived notions of “science” and “scientists”

One way to frame citizen science is through ideas about what science is and what scientists do. Stereotypes often lead to misconceptions that all scientists wear white coats in a lab full of beakers.

Start the discussion with the Draw a Scientist activity and have students explain their work.

Prepare to guide a discussion that addresses these notions and helps shift your students’ mindsets by adding to the table below:

Ask...	Be prepared with...
Where does science happen? What do scientists look like? What does a scientist do?	Examples of non-laboratory science and the scientists who do that work, for example: ecology, zoology, marine biology, geology, astronomy, climatology, etc.
What might be interesting about those areas of research? What might be fun about that type of science?	Examples of citizen science and citizen scientists to enforce the notion that anyone can be a scientist, and that science is both work and play.

Get Started

Why do scientists want us to do their work?

This question may come up when talking about citizen science with your students. Focus on scale: one scientist may be able to do research in one area, but what if s/he has a question about species that are distributed throughout North America, or even globally? What if s/he has a question that requires a lot of data? What if s/he's already collected hundreds of thousands or even millions of photographs and needs information from each one? Citizen science is a chance for people to help answer BIG scientific questions, while doing something that interests them.

Q A

Brainstorm other questions that you have or you anticipate your students will have. Then consider how you would respond.

Assessment Check-in #1

Assessments can and should be administered both during (formative) and at the culmination of the learning experience (summative). This allows for changes in teaching tactics to ensure students are getting a full and comprehensive experience through citizen science. This is especially critical while teaching the science inquiry process, since each part is related to all other parts. For example, if students are unable to articulate the question they are helping to answer through citizen science, they lose the key lens through which to view and understand their experience.

Tools to help build your own rubric and assessment:

- The Buck Institute's Rubric for Rubrics is an excellent source for designing a rubric to fit your needs.
- Creating Authentic Assessments is also a helpful resource.

Create a rough rubric for evaluating your students' understanding of the value of citizen science and their role as scientists.

Criteria	1 - Approaches Expectations	2 - Meets Expectations	3 - Exceeds Expectations

ACT | workbook

Your Citizen Science Project

While participating in an existing citizen science project may seem straightforward, having a clear vision of how citizen science fits into the larger science inquiry process is key to maximizing the learning potential and success of the project. This could seem like a daunting task, especially when working with a citizen science project that may still be unfamiliar.

There are many ways to select a citizen science project. You can choose the project that your students are going to participate in, your students could select a project that interests them, or you could give your students a suite of projects to choose from. No matter how the project is chosen, there are some important things to keep in mind that can facilitate the selection process and make the project easier to execute with your class.

In this section

Your Citizen Science Project

Select a project

Define goals and constraints

To preserve the interest-driven nature of citizen science and foster ownership, allow students to participate in the project selection process wherever possible. Clear parameters will ensure the academic integrity and logistic feasibility of the project, while a range of options will offer the chance for students to connect with a cause that is personally meaningful to them. You may wish to articulate specific requirements and the resources available, or provide broader guidelines, placing the onus on students to develop the plan.

Consider COPPA

The [Children's Online Privacy Protection Act (COPPA)] is designed to protect the personal information of anyone under 13 years old. If you're planning to participate in a citizen science project that has an online or app-based component, check the project's policies about COPPA. Your students may need to get parental permission, create one login for the entire class, or be able to create their own accounts.

- Keeping the Kids Involved: A Look at COPPA and Citizen Science

Before involving your students, define some of your goals and constraints:

Goals	Constraints
(curricular or academic goals, content areas, inquiry skills, field trips, etc.)	(technology, budget, ability to travel, length of project, materials, COPPA, etc.)
• ____________	• ____________
• ____________	• ____________
• ____________	• ____________
• ____________	• ____________
• ____________	• ____________
• ____________	• ____________
• ____________	• ____________
• ____________	• ____________
• ____________	• ____________
• ____________	• ____________
• ____________	• ____________
• ____________	• ____________

Your Citizen Science Project

Select a project

What will excite your students?

Keep in mind that different citizen science projects will be compelling to different types of learners. Some might be interested in the subject matter of the project, while others might be more engaged by the tools used to participate.

Your educational setting is another important factor when deciding on a citizen science project. To learn how other educators have selected and implemented citizen science to match their setting, see the Educator Case Studies section.

You can explore possible projects at scistarter.com. Be sure to look at what curricular materials and background resources the project itself provides.

Tools to help you and your students narrow in on a project:

- Pros vs Cons - Analyze and compare a group of ideas.
- What Project Should We Pick? (PDF) This template is designed to help students find projects that fit within the constraints/requirements of the class, as determined by the teacher. The teacher should fill out the left column of the table; the students will fill in the remaining columns. See an example here.

Or, California Academy of Sciences has created lesson plans to support your implementation of several citizen science projects.

- Big City Birds - Join a community of citizen scientists working to understand how different environments influence the location of city birds.
- Seasons of Change - Learn about and investigate seasonal changes in plants to help scientists understand how climate change is affecting the timing of phenological events.
- Galaxy Zoo-keeper Training - Join a community of over one million online citizen scientists working with astronomers to understand galaxy formation by classifying galaxies according to their shapes and characteristics.
- Explore, Explain, and Sustain Life - Join forces with everyday people from around the world to explore, explain, and sustain life on this planet, starting with the biodiversity of your schoolyard.
- Choose Your Own Adventure in Citizen Science - Thoughtfully determine what citizen science project to participate in and then to join that community to help answer a scientific question.

Use the table on the next page to organize your thoughts about possible projects.

Your Citizen Science Project

Select a project

Compare possible projects to propose to your students.

Citizen Science Projects and Inquiry Skills	Making Observations	Questioning, hypothesizing, and modeling	Developing a plan	Investigating and gathering data	Analyzing, interpreting, and thinking critically	Organizing evidence and communicating results
Celebrate Urban Birds	✓		✓			✓
Galaxy Zoo		✓		✓	✓	
Project BudBurst	✓	✓	✓	✓	✓	✓
Create a Project on iNaturalist	✓	✓	✓	✓	✓	✓

ACT | workbook

Assessment Check-in #2

Check that students understand what project they have chosen and record their summary here:

"We chose to participate in the ______________ (project name) project. We will be studying ______________ (research topic/question) by ______________________________ (how you plan to collect data)."

Assessment is most effective when it is diverse in scope and delivery. In addition to evaluating students directly, teachers can equip students with the skills to assess themselves and one another.

The following tools can be used to assess the citizen science learning experience, including evaluation of both the mindsets and skills developed along the way. Some of these tools can be used as-is or modified slightly for individual classes; others can be used to develop new, original assessments.

More assessment tools:

- Citizen Science Impacts Rubric (PDF) This rubric is designed for you to determine your goals and intended outcomes around engaging students in citizen science prior to participating in a project. As you set your goals, you will then decide how to assess and measure those outcomes.
- Student Scientific Inquiry Skill Building Indicators
This tool can be used in many ways. It can guide your ongoing assessment of the inquiry skills. It can also be deployed to inform your assessment of the inquiry skills included in the Citizen Science Impacts Rubric.

ACT | workbook

Your Citizen Science Project

Plan your project

Utilize existing resources

Many existing citizen science projects have tools and tutorials for preparing and training volunteers, and some have resources for teachers. Make sure to fully investigate the website of the project you're interested in to see what is available. It is especially important to follow the data collection methods outlined for each project to ensure the data your students collect are valid.

Use the space below to summarize the data collection requirements.

Prepare Students

It will be important to provide some training specific to the citizen science project that you or your students choose. This might include content information about a species or habitat or context about the research question(s) being asked.

Use the space below to brainstorm.

ACT | workbook

Your Citizen Science Project

Plan your project

Skill building

Citizen science projects provide wonderful examples of the scientific inquiry process at work; each project arose from a desire to better understand some unknown in the world. It is important to note that most citizen science projects focus on data collection as the primary form of contribution. Tasks like counting birds, observing bees, and documenting trees are easy ways for students to participate, but limiting youth to this one point in the inquiry science process can obscure their understanding of the big picture.

Depending on your project, students can be guided through extra activities that help foster the full range of skills. This will not only help further frame citizen science as a holistic process of exploration, but will also enhance the quality of students' participation and build confidence in their ability to contribute to research.

Outline how students will build skills through citizen science on the next page.

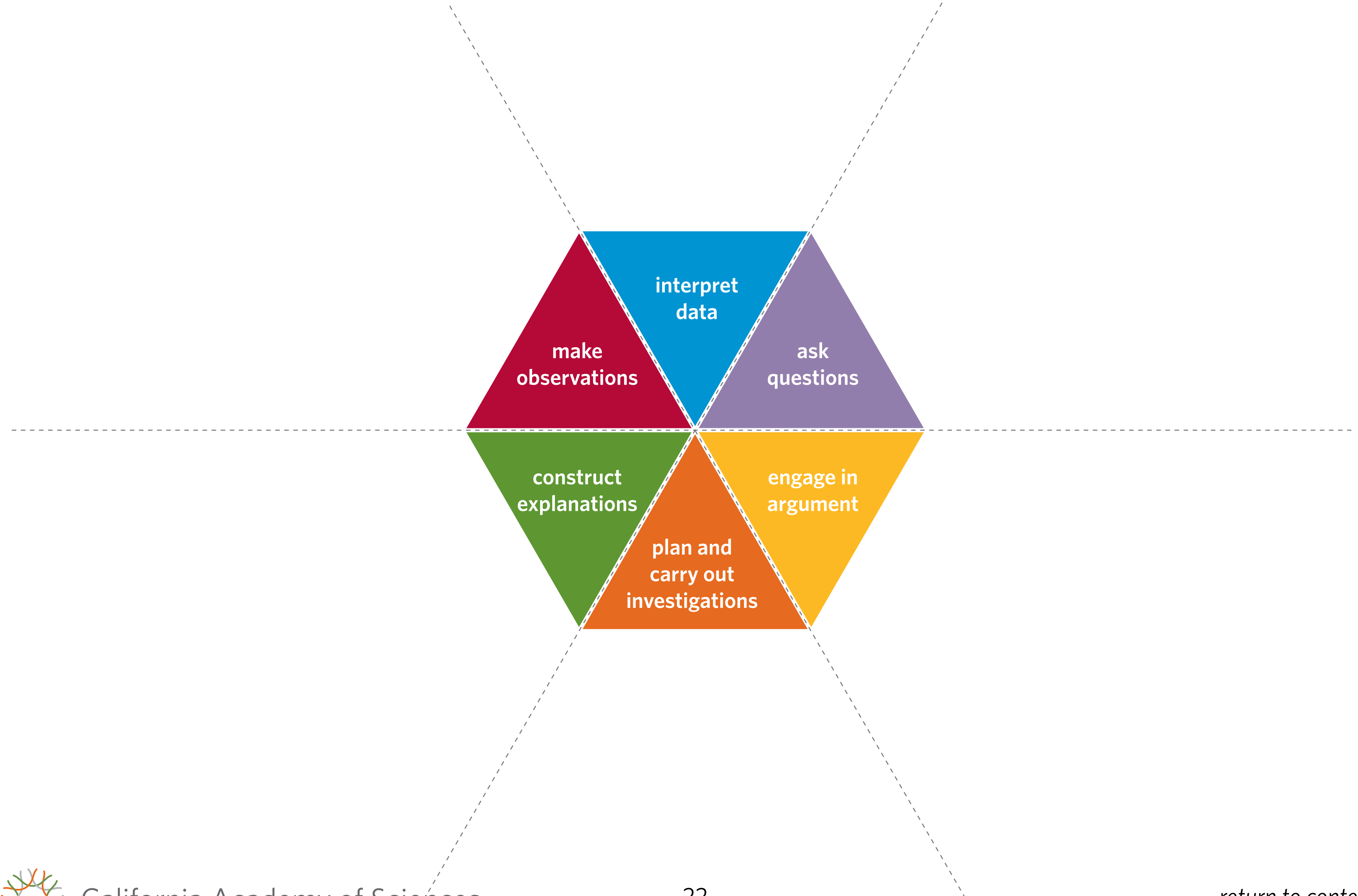
Below are some examples of opportunities for students to build scientific skills around particular content. You can adapt these activities to explore content related your chosen Citizen Science project.

- Observing Variation - Observe and document through scientific sketching.
- Field Guide to the Biodiversity of Your Schoolyard - Study local biodiversity, and recognize distinguishing features among species
- What Color is Your Leaf? - Collect and compare data about leaves from two different environments.
- Animal Behavior - Think critically about data collection and how to use your data to answer questions about animals you observe around you.
- Discovering Rainforest Locations - Compare maps showing worldwide temperature, precipitation, biodiversity, and soil nutrition levels to predict where on our planet's rainforests are located.
- Create a Campaign - Take action on a local or national cause you care about by creating a campaign.

Your Citizen Science Project

Plan your project

Use the space below to outline opportunities within your chosen project to build students' inquiry skills.



Assessment Check-in #3

In addition to assessing subject matter content, it may be helpful to consider the mindsets and skills that participating in citizen science fosters and strengthens. These include curiosity, agency, critical thinking, civic engagement, collaboration, and fun! While being a citizen scientist does support the development of a large suite of 21st century mindsets and skills, focus on one or two that are most relevant to the project experience itself for the purposes of the assessment.

Some helpful tools may include:

- Citizen Science Student Reflection (PDF) This resource includes three options for students to reflect on the citizen science experience and communicate their thoughts in writing.
- Citizen Science Attitudes Pre- and Post- Survey (PDF) To gauge changes in students' attitudes toward science, this survey should be administered before and after they participate in the citizen science unit. Included here as a Word document, consider transferring these statements into a web-based survey tool for ease of data analysis.
- Collaboration (PDF) and Critical Thinking (PDF) from the Buck Institute are aligned to the Common Core State Standards. While they are easily tailored to your desired learning outcomes, they are also sufficient to be used as-is.
- Post-Project Reflection for Teacher (PDF) Borrowed from the D3 Design Thinking Toolkit by Commonstudio, but useful for reflecting on participation in Citizen Science, this document will provide support in assessing your project for strengths and areas for potential improvement shortly after it has been implemented. View a sample here (PDF).

Your Citizen Science Project

Get organized

Create a timeline

Having a plan is key to be effective citizen scientists. Help your students think carefully about what is being asked of them and how they can best prepare to participate.

What steps are necessary to prepare for and carry out your citizen science project? In what order do those steps need to happen?

Create a rough timeline for the project. Consider:

- your planning time
- getting materials
- daylight savings time and school holidays
- your end date

Planning and Timeline (PDF) This template is designed to help plan out the steps in getting ready for your citizen science project and for participating in the project. Students can assign jobs, create a timeline, and think critically about what they need to do to make the project a success.

Now

Your Citizen Science Project

Get organized

Assign jobs

Having a specified job empowers students to take ownership of the citizen science project. What roles will need to be filled to make sure the project runs smoothly? Will students take turns doing each job, or become experts in one? Possible jobs could include:

- Supply gatherer(s)
- Supply checker(s)
- Primary data recorder(s)
- Environmental data recorder (temperature, wind speed, etc.)
- Supplementary data recorder (number of participants, time participating, etc.)
- Project manager (someone to keep track of the steps and let students know what to do next)
- Data checker(s)
- Data uploader(s)
-
-
-
-

Gather tools

Have your students brainstorm what supplies they will need and what potential tools might make their participation easier. Will they need clipboards, identification guides, measuring tapes, etc.? Some resources may be supplied by the citizen science project, while others must be made or acquired.

Stay focused while outside (PDF) Group management can be more difficult with the added distractions of nature. Careful planning and clear expectations help will make working outdoors easier, more productive and more fun. (Used with permission from Strauss, A.L., Homayoun, T., Meyer, R.L., Nippolt, P.L., Oberhauser, K., Peterson, C., Rager, A.,& Young-Isebrand, E. (2015). Driven to Discover: Facilitator's Guide to Citizen Science. St. Paul, MN: University of Minnesota Extension. Download here)

Your Citizen Science Project

Get organized

Make a checklist

Checklists are a great way to organize resources and ensure nothing is forgotten. Most of the Citizen Science projects in which you will take part will provide checklists, planning tools, and equipment lists. It may be helpful for you to consider all of the scenarios that may apply to your situation.

Some of the sample lists are far more detailed than will be needed, others may be too simple, but all are good examples of thoughtful and thorough planning:

- Citizen Science Checklist Template (PDF)
- Simple checklist that focuses on supplies and notification (Source: The New Teacher Noggin)
- Detailed professional field planning list (Source: Dr. James A. Fox Department of Anthropology, Stanford University)

It's important for instructors to prepare as well, especially if the citizen science project involves going off campus. Items might include:

- First aid kit
- Supplies
- Transportation
- Rules
- Buddy system
- Chaperones
- Notify your administrator
-
-
-
-
-
-

ACT | workbook

Assessment Check-in #4

Assessment tools may include rubrics, checklists, observation, portfolios, or quizzes. Whatever the matrix of carefully selected tools, they are created to optimize the feedback that students receive about what and how they are learning and growing.

The purpose of assessment is to improve student learning through effective feedback. Assessment should be ongoing; collect and interpret data for the purpose of improving understanding and adjusting teaching. Pause to organize what trends you have found in your students' progress around citizen science.

Use the space below to consider what else can be improved and what assessment still needs to happen.

Expand the Experience

Where can you build on or add in the aspects of the scientific inquiry process that the citizen science project does not explicitly address? How can students continue to participate outside of class time?

In this section

- Maintain a scientist's notebook
- Communicate results
- Become a regular
- Assessment Check-in #5

Expand the Experience

Maintain a scientist's notebook

Have your students keep a log while participating in the citizen science project. Students should include what they noticed, anything new they learned, and especially what questions they thought of while participating. Once the project is complete, students can use these logs to categorize questions as those they could try to answer based on the data collected, those related to the project that would require different data to answer, or those that require background research. Follow up could include:

- **Questions to answer based on data collected:** Have students develop hypotheses based on their question, then analyze their data. This could be as simple as looking for trends or as complicated as running statistics. Students can graph data in a variety of ways to help visualize results.
- **Questions related to the project that would require different data to answer:** Have students develop hypotheses based on their question, then brainstorm what methods and protocols they would have to follow to accurately answer it. What sort of data would be needed to support their hypotheses?
- **Questions that can be answered with some research:** Give students an opportunity to use the library or a computer to find out more about their topic.

Notebooking resources:

- Science Notebook Corner - Learn how the practice of keeping a notebook can help your students think more scientifically and recognize patterns in their observations. Sample our easy-to-implement strategies to help you get started with science notebooking.
- Scientist's Notebook (PDF) This template can be used alongside the citizen science project to help your students think more deeply about their process and develop new questions.

ACT | workbook

Expand the Experience

Communicate results

Have your students communicate the results of their participation in a citizen science project using the evidence from the data to support their conclusions. There are many options for how to share results: write a report, create posters, give a presentation, or start a social media campaign, to name a few examples.

Construct a Scientific Explanation (PDF) Use this template to help students construct a strong scientific explanation using three essential elements: a claim, evidence, and reasoning.

Become a regular

Even if the semester is over, students can continue to collect data and connect with the vast citizen science community on their own time. Look out for local citizen science events, like BioBlitzes or bird counts, to continue to engage students in hands-on investigations. Online project platforms also make it easy to contribute and participate. Your students may even discover something new, like the 10-year-old who uploaded the first recorded sighting of a Social Flycatcher in California to iNaturalist.

In addition to the large-scale projects below, check your local parks or nature centers for upcoming events.

- National Park BioBlitz - The National Park Service hosts a nation-wide quest to discover and document biodiversity with BioBlitzes all over the country.
- BioBlitzes: Discover Nature - California Academy of Sciences also organizes events around the Bay Area and beyond.
- Christmas Bird Count - The nation's longest-running citizen science bird project fuels Audubon science throughout the year.

Assessment Check-in #5

Imagine assessment and learning as two sides of the same coin; as students engage in an assessment exercise, they should learn from it as well.

Use the space below to consider what you want your students to gain from a final project and how you will assess them.

Modern Media Blitz: Sharing Your Stories - Craft a mini-media outreach plan. Share your citizen science experiences and findings, recognizing that the same story can and should be told in different ways to different audiences in order to maximize its impact.

Educator Case Studies

In this section, you will hear directly from four educators who participated in a citizen science program with their students and shared their reflections on the process. Each case study describes the educational setting, project details, and both scientific and learning outcomes.

Montgomery High School Ecology Project

Written from the experience of a biology teacher at Montgomery High.

School Name	Montgomery High School
Location	Santa Rosa, CA (San Francisco Bay Area)
Total Time	3-4 weeks
Subjects	Biology
Grade Level	10th-12th
Participants	150 students

Experience

The Montgomery High School Ecology Project on iNaturalist was a great way to engage my students in observations of the natural world and to connect them to local scientists.

iNaturalist is essentially a collection of digital field notebooks, made by individual users, but shared among a large community. This makes it an ideal platform for technologically-minded and social media-savvy teenagers, and is more likely to engage them than paper datasheets. My students clearly understood they were collecting research-grade data during this service-learning project due to the easy-to-use format of the project website and smartphone applications, and the communication and species identification they received from the corps of naturalists online. Scaffolding and specific guidelines were presented to help every student document biological observations in their local community.

The project was conducted as a "competition" to collect the most research-grade data, with the additional incentive of a "Unit Exam Pass" for overall observations, effort, and teamwork. I allowed my students to use their iNaturalist.org accounts during class time, which led to increased engagement and enthusiasm. They were also given time to present their observations and data reports to the class as a whole.

This project aligned well to our existing unit and class goals, and I was able to use iNaturalist to introduce a unit on classification. Additional activities connected to the project included a computer-based webquest, PowerPoint citizen science technology training, lectures, video clips related to invasive species and biodiversity, and a field trip to an adjacent semi-rural site. I also invited guests from the Audubon Society and local iNaturalist participants who had been assisting with online identifications, to help reinforce the importance of community connections in science research.

To address the issue of access to technology, my students completed a survey noting their access to mobile and digital technology. I then organized them into groups of three, assuring that at least one student per group had iNaturalist app availability so the group could upload their observations.

"After learning about iNaturalist, I established an ecology project using the app for my high school students. This project covered classification, ecology concepts, and help students build technology and inquiry skills. They saw how individual observations in their hometown contributed to the bigger picture of understanding species distributions in the face of global change."

Outcomes

The learning outcomes for my biology classes at that time were focused on themes of classification, ecology, technology and inquiry. These themes were embedded in a larger project, which included the use of field lab notebooks and plant presses.

Online photos and written exchanges between my students and global naturalists were shared via the iNaturalist online platform. Students were able to obtain research-grade data and contribute these to the global scientific community.

One observation in particular piqued the interest of the scientific community: A student posted a picture of a collared lizard in Howarth Park in Santa Rosa, which caught the attention of scientists because the lizard, native to the desert east of the Sierra Nevada, was far from its usual home range. Scientists suspected the lizard was a pet that was released into or escaped to the park. Not only was this observation exciting, but it also helped highlight an important learning goal in our unit. My students realized that as climate changes, collared lizard populations are likely to move further north and as a result, will be found more frequently in our Santa Rosa region in the future.

LiMPETS Sandy Beach Monitoring		
	School Name	Half Moon Bay High School
	Location	Half Moon Bay State Beach
	Total Time	~4 hours per monitoring event
	Subjects	Marine Ecology, AP Environmental Science
Written from the experience of a science teacher at Half Moon Bay High School.	***Grade Level***	11th-12th
	Participants	30 per class

Experience

The Long-term Monitoring Program and Experiential Training for Students (LiMPETS) allowed my students to explore citizen science and understand the value of contributing to the conservation of marine ecosystems.

The LiMPETS program provides training, lesson plans, and tools for monitoring a costal ecosystem. Staff can even be scheduled to teach a preparatory lesson or join the class in the field, which can be especially helpful the first time. This was the case for our class, where an advance overview lesson was led by staff from LiMPETS. The students were given a map of all the monitoring locations, graphs of currently existing survey data, and photos connecting this data to environmental changes. We discussed human activities such as oil and sewage spills, to highlight the importance of consistent, long-term data sets as well as the way these resources are used by scientists and policy-makers.

Before the day of the field trip, one class period was devoted to introducing students to the details of the project, expectations for field-data collection, and skills practice.

Anticipation of the field study portion of this project is motivation enough for students to engage in the preparatory activities. Once in the field, students have the chance to practice using the materials (cores, sieves, calipers) before collecting data. As a class, we completed a field log that included details on the location and weather conditions before setting up the sample area.

Students worked in five small groups , with each group responsible for one transect line containing 10 sampling locations. Each group collected a set volume of sand at each sampling location on the beach and then used sieves to isolate the mole crabs. Each set of crabs was sexed, measured, and logged in the data table.

In class on the following day, my students entered their data on the LiMPETS program website. Groups were then asked to develop a question about either long-term population changes at our monitoring site or about comparisons between sites. They further examined their data, using the LiMPETS web portal to create graphs related to their question. They also created a final presentation to share what they discovered with the rest of the class.

Outcomes

This project is very productive: my students learned new skills, science content and were able to gather a large data set to contribute to the monitoring program during a single 2 hour field trip. After only a few days, they learned details of Pacific mole crab biology and sandy shore ecosystem structure. They developed skills like how to measure accurately with calipers, create a detailed field log, and how to set up a randomized sample area using transects. They also were able to contribute data to the scientific community and investigate datasets to answer student-generated questions.

"My students loved participating in this project and wanted to do multiple monitoring events during the year. It was a great opportunity that allowed them to develop their field science skills and apply them toward a project that helps assess the wellbeing of our coast."

This project can work well as a stand-alone project or as part of a marine science or sandy shore unit of study. It can also be easily expanded into a year-long class project. It's a great opportunity to engage your students and provide them the opportunity to collect data that will become part of a long-term data set used to protect California's beach ecosystems.

Mountain Lake Monitoring		
	School Name	Hamlin School
	Location	San Francisco, CA
	Total Time	~1 hour per monitoring event
	Subjects	Science
Written from the experience of a science teacher at Hamlin School.	**Grade Level**	6th
	Participants	15 per class

Experience

My class participated in a place-based citizen science experience, focused on Mountain Lake in the Golden Gate National Recreation Area in San Francisco. My students chose one of six different citizen science projects to monitor the lake during three site visits.

We kicked off the school year with a brainstorming session around how humans have impacted their environment. They first developed questions related to these environmental changes: Did the environment change quickly? How do we know? How long have scientists been monitoring the environment? They then challenged themselves to act as citizen scientists and help monitor these changes in their own community.

My students learned about Mountain Lake history through an interactive ebook created through a partnership with the Presidio Park Trust and Hamlin School. They then learned about how humans have impacted and changed the lake over time.

One of the projects my students participated in was the Great Sunflower Project. As a part of their citizen science experience, they monitored plants and observed different pollinators. During monitoring, they noted the start and end time and tried to identify the pollinators. One of the goals of this project is to analyze the number of visits that each pollinator makes to the plants.

Another citizen science project that my students participated in is the California Phenology Network. Once a location has been established, plants can be monitored year after year. There are five different plant species to monitor at Mountain Lake. Each species is recorded during the different seasons to see how these plants are changing due to climate change.

My students also participated in a Migratory Dragonfly Partnership where they identified and watched dragonflies that are located around Mountain Lake. This project has excellent data sheets and guides on the different types of Dragonflies to help students get to know these invertebrates.

Outcomes

My students studied and helped monitor local habitats in their community. This experience allowed them to understand how habitats are changing over time. They also shared their data with scientists, which can help to determine effects on global warming and changes in local population size. My students also created artistic signs in their art classes that were placed around Mountain Lake, to help inform the public about changes to the lake over time and how they too can care for the lake.

" My students were able to act as scientists. Their data contributed to our understanding of how the world is changing and how we can monitor that change. They also connected to their local habitat and felt like they are making a difference at a young age, which will inspire them to care for their environment in the future."

This is an example of place-based citizen science. The teacher and her students chose to center their experience around one location and use it as a home base for participating in several different citizen science projects. This approach allows students to fully explore a local habitat by investigating and familiarizing themselves with the many biotic and abiotic features found there.

ACT

Science Action Club		
	School Name	Orange Park Boys & Girls Club
	Location	South San Francisco
	Total Time	8-15 weeks
	Subjects	Science
	Grade Level	5th-8th
	Participants	20 students per site

Experience

Designed by the California Academy of Sciences, Science Action Club (SAC) is a high-impact STEM learning program that provides professional development and teaching kits to middle school afterschool providers. SAC features environmental science curriculum modules that spark interest in scientific exploration and empower youth to conduct active research as citizen scientists.

Youth spend about twenty minutes of each club session making nature observations, documenting their findings, and submitting their results to nationally-recognized citizen science projects like the Cornell Lab of Ornithology's eBird project, NASA's S'COOL project, and iNaturalist.

At a recent SAC session at Orange Park Boys & Girls Club, youth started their day by heading outside and performing a bird count. Using binoculars and an ID-guide on their iPad, they observed and documented a variety of birds in their schoolyard. After sharing and comparing observation notes, the youth then grouped into teams and played a game to explore how penguins' feathers help them survive in marine environments. Continuing their investigation of bird feathers, SAC youth then tested different methods of cleaning oil from feathers. This hands-on activity allowed them to understand the environmental implications of oil spills and to discuss solutions in the event of a cleanup.

As youth observe and document nature in their local environment, they join a community of global citizens that work together to protect the planet.

Outcomes

Written from the experience of a Science Action Club afterschool instructor.

Science Action Club combines hands-on learning with gathering data for organizations that reach farther than our club or even the California Academy of Sciences. The afterschool environment provides a unique opportunity for young people to get outdoors, explore the natural world, and participate in authentic science research without the constraints of regular school day structures.

At the Orange Park Girls and Boys Club, my youth developed ways to identify clouds by just looking up at the sky. They also observed a diversity of arthropods and birds in local habitats. The skills they developed have allowed them to report to NASA and to communicate with other scientists about what they found in their neighborhood. Overall, the program has been a great balance between scientific practice and a practical understanding of the topics they have been studying.

"I have watched my students identify clouds, bugs, and birds. I have watched them develop their observation skills and push themselves outside their comfort zone. They have had a lot of fun doing it. I am grateful because they have been able to study things in a way that I never got to at their age, so we have been able to learn together."

Citizen Science and the Standards

Science and Engineering Practices

Through citizen science, students can engage in several of the Science and Engineering Practices (SEPs)[1] of the Next Generation Science Standards (NGSS), and strengthen the citizen science skills outlined in this toolkit. The examples below illustrate a few ways educators have leveraged projects and curricula to give students the opportunity to engage in the SEPs. You may find or build similar connections in other citizen science projects.

NGSS Science Practice	Brief Description of Practice (NGSS Appendix F)	Examples from classroom citizen science projects
Asking Questions *	• Ask questions based on observations. • Ask questions about relationships among variables, for example, "What would happen if...?" • Identify testable versus non-testable questions.	Students participating in LiMPETS are asked to develop questions based on their experiences at the sites and the data they have collected. Students may ask questions about long term population changes, or about comparisons between sites. Educators can support students in developing and identifying testable questions that they may be able to answer with data by using some key criteria: • Answers are observable, measurable, repeatable. • Questions are comparative, descriptive, or about a relationship or correlation. Educators can recognize and value non-testable questions by posting them as "to research" and/or "to ponder," and students can be encouraged to return to them as the project continues and their interest and knowledge in the subject grows.

1 Not all of the eight SEPs are included here. The exclusion of a particular practice does not mean that an educator can not build in an opportunity for students to engage in that practice—only that the practices listed are those that have clear and explicit opportunities within projects supported by the materials in this toolkit.
* This example also supports related practices identified in the Common Core Mathematics Standards. Read more about connections between the NGSS and Common Core: NGSS@NSTA.

NGSS Science Practice	Brief Description of Practice (NGSS Appendix F)	Examples from classroom citizen science projects
Analyzing & Interpreting Data *	• Represent and display qualitative and quantitative data using a variety of methods • Use data displays to identify relationships. • Analyze data to provide evidence for explanation and argument.	In the Science Action Club (SAC) unit *Bugs in Your Schoolyard*, middle school students record observations of arthropods using descriptions and measurements of appearance and location. Students are supported in using these two types of data to make a conclusion about the identity of the specimen. Students gathering data for LiMPETS can be encouraged to query either their own class data set or the larger project data set in order to answer their own testable questions (see above). Students may also try out various methods of displaying data, and evaluate which representation is the most useful in answering their question or helping them to personally understand the phenomenon.
Using Mathematics & Computational Thinking †	• Organize data to reveal patterns. • Describe, measure, estimate, and graph quantities to address a question or problem. • Create graphs and charts. • Apply mathematical concepts and/or processes to scientific questions.	Students taking part in the Monarch Larva Monitoring Project (MLMP), can take an active role in ensuring that their samples are random by following a sampling protocol at their data collection site. For instance: • Choose a random direction (use a randomizer like a die or spinner) • Walk in a straight line across the site (pick one object on the other side of the site to walk toward) • Count the number of plants on which you search for monarchs (observe and include in this count any plant within reach of your outstretched fingertips as you walk your straight-line path). Data that students submit in the MLMP project also includes calculations of milkweed density at their site.

* This example also supports related practices identified in the Common Core Mathematics Standards.
† This example also supports related Anchor Standards identified in the Common Core ELA Standards. Read more about connections between the NGSS and Common Core: NGSS@NSTA.

NGSS Science Practice	Brief Description of Practice (NGSS Appendix F)	Examples from classroom citizen science projects
Constructing Explanations * †	• Use evidence, including measurements and observations, and established scientific knowledge, to support an explanation. • Construct an explanation of observed relationships. • Revise an explanation based on new or changing evidence.	Project BudBurst asks participants to collect data about the timing of different phases in the plant life cycle (phenophases) to help the scientific community understand the connection between seasonality and changes in Earth's climate. Students experienced in collecting and submitting BudBurst data can take a look at the larger Data Map. Educators may want to give students a period of time to notice patterns and trends in the data, then support them in constructing possible explanations for the patterns they observe.
Engaging in Argument from Evidence * †	• Construct a convincing argument that supports or refutes claims for explanations about the natural world. • Critique explanations of peers by citing relevant evidence.	While participating in Project BudBurst, educators may give students a chance to share their explanations (claims) supported by their BudBurst data (evidence) with other groups. Educators can scaffold the discussion among and between groups with sentence frames for productive discussion. Teacher talk moves (Michaels and O'Conner, 2012, p. 11)[2] can also help facilitate a whole-class discussion or debate around this data and what it seems to show.
Obtaining, Evaluating, & Communicating Information * †	• Obtain scientific information via text and other media. • Evaluate and combine information to explain phenomena. • Communicate scientific information orally and/or in written formats using a variety of media.	In Science Action Club, students wrap up each Schoolyard Safari by creating a Critter Chronicles video to share with other student scientists. In the video, they share answers to questions including: • Where did you go to find arthropods? • What collection tools did you use and how did you use them? • What types of things did you find today? • What challenges came up and how would you do it differently next time? In curricula like *Bugs in Your Schoolyard* that use iNaturalist, as well projects like eBird that use Merlin, students engage and communicate with these online communities, making specimen identifications and submitting their findings to nationally-recognized citizen science projects.

* This example also supports related practices identified in the Common Core Mathematics Standards.

† This example also supports related Anchor Standards identified in the Common Core ELA Standards. Read more about connections between the NGSS and Common Core: NGSS@NSTA.

2 Michaels, S. &; O'Connor, C. (2012). *Talk Science Primer*. Cambridge, MA: TERC. Retrieved from http://inquiryproject.terc.edu/shared/pd/TalkScience_Primer.pdf

Crosscutting Concepts

Citizen science projects are rich, complex experiences that involve real world data collection, observation, and analysis. In the following table, NGSS Crosscutting Concepts (CCCs) commonly addressed in citizen science experiences are listed, as well as projects that, through their content and methods of engagement, provide exemplary connections to one or more CCCs.

Crosscutting Concept	Brief explanation from *A Framework for K-12 Science Education* (NGSS Appendix G)	Example Citizen Science Project
Patterns	"Observed patterns of forms and events guide organization and classification, and they prompt questions about relationships and the factors that influence them."	In projects where students are making and submitting regular observations using a set protocol (for example NASA's S'COOL project), there are opportunities to identify patterns across observations, and begin to consider factors that might influence these patterns.
Cause and effect: Mechanism and explanation	"Events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given context and used to predict and explain events in new contexts."	Arthropods in Your Schoolyard on iNaturalist focuses on gathering observations of arthropods in a variety of habitats. As students collect a larger number and wider variety of observations, they might begin to be able to predict the type of organisms they will find in a certain location, based on various environmental conditions (e.g. temperature, moisture, light). This type of prediction makes way for exploration into what arthropods need to survive in general, and how and why that might vary from species to species.
Scale, proportion, and quantity	"In considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system's structure or performance."	Some projects ask participants to take random samples of a local population, which adds to the understanding of the size and location of the larger, global population. These projects, including LiMPETS and MLMP, also allow the analysis of local data (the data collected by your own class) as well as making the larger data sets available. Participants have the opportunity to learn about population sampling, and to compare and contrast conclusions that can (or can't!) be made from smaller sets of local data vs much larger data sets.

Crosscutting Concept	Brief explanation from *A Framework for K-12 Science Education* (NGSS Appendix G)	Example Citizen Science Project
Systems and system models	"Defining the system under study--specifying its boundaries and making explicit a model of that system--provides tools for understanding and testing ideas that are applicable throughout science and engineering."	Data visualization can be used to model and study systems. Many projects offer interactive data visualization tools that students can manipulate, and sometimes populate with their own data, making it possible to look at a system in multiple ways. For example, eBird's multiple data tools allow the user to define the system using different boundaries based on time, geography, or type(s) of bird. More specifically, if the boundary of the system is drawn geographically, species populations may fluctuate based on other components of the system. Alternatively, if the system is defined as the population of all migratory birds observed, students might think about what how inputs to and outputs of that system changes over the course of the year.
Stability and change	"For natural and built systems alike, conditions of stability and determinants of rates of change or evolution of a system are critical elements of study."	Many projects allow for observations over extended periods of time, and make past observations from over an even longer period available for review. Project BudBurst is one such example, where seasonal change is the focus of observation, but year-to-year these seasonal changes happen at around the same time, so are relatively stable. One question of scientists using BudBurst data is: how much is this stable pattern actually changing over time?

Citizen Science Resources

These related links include guides for getting started with your own citizen science projects, indexes to existing citizen science projects that you can join, and a wide range of educational resources that accompany citizen science projects. The majority of the examples here are focused on life science; however, the resources for getting started apply to citizen science in whatever subject matter you decide to pursue.

In this section

Project Portals

Browse these websites to select a citizen science project that meets your needs.

Nature Watch	A portal to citizen science and nature-related activities designed for and taking place in National Forests.	USDA Forest Service
SciStarter	Matches people with projects that suit their interests and is a resource for finding citizen science projects of all types. Structured with project descriptions and accompanying blog by educators who have used the projects.	SciStarter
Your Wildlife	A portal to citizen science projects that explore the microflora and fauna that live on and in our bodies—our own human microecosystems. Students and members of the public explore "their wildlife" in projects such as The Bellybutton Biodiversity Project.	North Carolina State University, National Science Foundation
Zooniverse	A collection of internet-based citizen science projects to further science and the public understanding of science and of the scientific process. Projects hosted on Zooniverse range from astronomy to climatology to archaeology. Signature projects include Galaxy Zoo, Old Weather, and Planet Hunters.	Citizen Science Alliance

Communities

Explore these online communities to connect with citizen scientists around the world.

iNaturalist	A platform to record observations of plants and animals in nature, share what you've found, add sightings to citizen science projects, meet others with similar interests, learn more about nature, and contribute to a global dataset of biodiversity information.	iNaturalist and California Academy of Sciences
Public Lab	An online community where you can learn how to investigate environmental concerns, using inexpensive DIY techniques.	The Public Laboratory for Open Technology and Science
Project Noah	A platform for people of all ages to document wildlife with photography, connect to nature, and join "missions," or scientific investigations using observations submitted by the public and other science datasets. Contains resources designed for teachers.	National Geographic and NYU's Interactive Telecommunications Dept

Activity Books

Check your library for these books of ideas for citizen science lessons.

Citizen Science: 15 Lessons that Bring Biology to Life, 6-12	Offers flexible classroom activities for indoors or outdoors, designed to make data collection and analysis easy.	Trautmann et al., eds; NSTA Press (2013)
Citizen Scientists: Be Part of Scientific Discovery from Your Own Backyard	Covers four seasons of citizen science, with kid-friendly outdoor activities.	L.G. Burns; Henry Holt and Company (2012)

Online Guides and Professional Development

Take advantage of many other online guides, toolkits, and opportunities for professional development.

Choosing and Using Citizen Science: A Guide to When and How to Use Citizen Science to Monitor Biodiversity and the Environment	A handbook for educators, community members, and scientists with step-by-step guidance on designing effective citizen science projects.	Scottish Environment Protection Agency Pocock, M.J.O., Chapman, D.S., Sheppard, L.J. and Roy, H.E.Centre for Ecology & Hydrology. ISBN: 978-1-906698-50-8, 2014, 28pp
Citizen Science Academy	An online professional development resources for educators to support effective implementation of citizen science projects and activities that focus on ecology and environmental sciences. Includes courses for informal and formal educators, modules, tutorials and community forums.	National Ecological Observatory Network (NEON)
Field Investigations: Using Outdoor Environments to Foster Student Learning of Scientific Processes	A guide for K-12 teachers to introduce their students to the methodologies used for scientific field research and to guide them through the process of conducting field studies.	Association of Fish and Wildlife Agencies' North American Conservation Education Strategy; Pacific Education Institute
Guide to Citizen Science	Written by scientists and educators, covers developing, implementing, and evaluating citizen science for biodiversity studies.	Natural History Museum of London; Natural Environment Research Council's Centre for Ecology & Hydrology

Additional Information

Continue with more background information on citizen science.

Citizen Science Association	An organization of science and education professionals who design and implement citizen science programs, designed to share best practices, ideas, and to foster collaboration	Citizen Science Association, led by a multi-organization governance committee
Citizen Science: Real world applications for science students	A short and easy-to-read index to some notable citizen science projects organized by grade level.	University of North Carolina School of Education
Frontiers in Ecology and the Environment Special Issue: Citizen Science – new pathways to public involvement in research	The August 2012 journal issue is entirely devoted to citizen science, with articles ranging from data quality to engaging students to case studies.	Ecological Society of America; various authors; Frontiers in Ecology and the Environment (2012): 10(6)
How Science Works	An iTunesU course with in-depth look at the complexities and processes of the scientific method. Includes information for teachers and a resource library.	California Academy of Sciences; University of California Museum of Paleontology

EXTEND

Links in this Toolkit

PDF Worksheets	Link	Page
Citizen Science Attitudes Pre- and Post- Survey	https://goo.gl/JuEjnY	23
Citizen Science Checklist Template	https://goo.gl/cruFQH	26
Citizen Science Impacts Rubric	https://goo.gl/nQneuP	19
Citizen Science Student Reflection	https://goo.gl/0qjOXj	23
Collaboration Rubric	https://goo.gl/1oaC7c	23
Constructing a Scientific Explanation	https://goo.gl/TWyXAH	30
Critical Thinking	https://goo.gl/McqJK1	23
Planning and Reflection Sample	https://goo.gl/qrWJ3N	23
Planning and Timeline	http://goo.gl/un8yWs	24
Post-Project Reflection for Teacher	https://goo.gl/cYeCPd	23
The Buck Institute's Rubrics for Rubrics	https://goo.gl/mw9kyb	14
Scientist's Notebook	http://goo.gl/JoubJY	29
Sentence Stems	https://goo.gl/GhlHP9	42
Stay Focused While Outside	https://goo.gl/cZ3MyZ	25
Student Scientific Inquiry Indicators	https://goo.gl/w83DNh	19
What Project Should We Pick?	http://goo.gl/5r7iEm	17
What Project Should We Pick? Sample	http://goo.gl/Roh43m	17

Citizen Science Toolkit was developed by the California Academy of Sciences. First published in partnership with the Pearson Foundation and revised in 2015.

Project Leads
Laura Herszenhorn, Rebecca Johnson, and Alison Young

Writers
Andrew Collins, Krista Doersch, Laura Herszenhorn, Rebecca Johnson, Clea Matson, and Alison Young. Special thanks to our partner educators for sharing their case studies.

Designers
Krista Doersch and Kristen Kong

Photography
All photos are public domain images or were taken by Academy staff with written consent.

CALIFORNIA
ACADEMY OF
SCIENCES