A DESIGN PROCESS FOR ENGAGING STUDENTS IN CITIZEN SCIENCE IN THEIR SCHOOLYARD

THE SCHOOLYARD SITES CURRICULUM WORKBOOK

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University of New Hampshire Land, Water and Life Acknowledgment

As we all journey on the trail of life, we wish to acknowledge the spiritual and physical connection the Pennacook, Abenaki and Wabanaki Peoples have maintained to N'dakinna (homeland) and the aki (land), nibi (water), olakwikak (flora) and awaasak (fauna) which the University of New Hampshire community is honored to steward today. We also acknowledge the hardships they continue to endure after the loss of unceded homelands and champion the university's responsibility to foster relationships and opportunities that strengthen the well-being of the Indigenous People who carry forward the traditions of their ancestors.

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Preface

Schoolyard SITES is a community partnership STEM teacher professional development program and research study at the University of New Hampshire. The program partners elementary teachers with UNH Extension science volunteers to bring locally relevant citizen science projects to their students. Participants learn together as a team and gain experience with scientific investigations and content that they will use later in their classrooms. With support from the volunteer, teachers design and teach a citizen science curriculum for their students that is relevant to the school district's curriculum and school site. This workbook has been compiled based on three years of experimental testing and refinement during the Schoolyard SITES project. If there is any one thread that we hope will connect it all, it is that the process of creating a new curriculum should be deliberate, with each seemingly minor decision being handled with a strong sense of intentionality.

As we sort through our collection of files, trying to figure out how to organize them and what modifications are necessary to pull them together, the inevitable question arises — who is this workbook for? We need something that meets the needs of our team and the participating teachers and Extension volunteers. However, it is equally important to us that we can share our experiences with a wider audience, including other teachers, community volunteers, Extension programs throughout the country, academics, and other professional development providers. Due to this varied group of potential users, the language that we use is meant to bridge the spectrum. Our rationale is rooted in education research and the landscape and history of national standards, so our language here in the preface leans toward the academic side of the spectrum. The workbook contents come from our in-person workshops, which are inherently conversational, and this is reflected in the language used throughout all other sections.

National Context & Rationale

The current science and engineering K-12 education standards, the Next Generation Science Standards (NGSS Lead States 2013; National Research Council [NRC] 2012), places a more concise focus on the incorporation of science practices into both curriculum and instructional pedagogy (NGSS Lead States 2013; NRC 2012). NGSS differs from prior national science standards (NRC 2000 & 1996) and acknowledges that student learning is improved when students are engaged in the authentic science practices from which the disciplinary core ideas were originally developed (NRC 2012). Another fundamental principle of NGSS is that K-12 students engage in science learning that is relevant to their everyday lives, hence demanding real-world, problem-based learning.

To achieve the new vision of NGSS, reforms call for professional development that promotes teachers' understanding of science as a way of knowing that is achieved through their firsthand engagement in the science practices and thus mirrors what is expected of their students (NRC 2012). An emerging professional development approach uses citizen science projects as a means for participants to generate independent investigations, thereby allowing them to experience authentic science research (Bennett 2010; Paige et al. 2012; Trautmann, Shirk, Fee, & Krasny 2012). In addition, research indicates that ongoing support and professional development helps teachers transform their instruction to reflect the vision of NGSS (Houseal et al. 2014; Miller et al. 2015). Support may come in various forms. When teachers are partnered with content experts, such as scientists and community-based specialists, they gain ongoing support and a deeper understanding of authentic science investigations (Houseal et al. 2014; Trautmann et al. 2012). Research also shows that connecting teachers to community-based science experts has a positive impact on student learning (Bouillion & Gomez 2001; Honwad, Koper, Abrams, & Middleton 2015).

The Schoolyard SITES program is designed to address identified needs of elementary school teachers (Plumley 2019), for professional development in NGSS. The program also capitalizes on emerging trends in citizen science programs and their associated learning outcomes (National Academy of Sciences 2018), in conjunction with new efforts to build connections between Cooperative Extension community volunteer programs and science programs in schools. Research in science education indicates that teacher self-efficacy is enhanced not just through science content knowledge but also through collaboration with content knowledge experts (Watters & Ginns 2000).

Schoolyard SITES Model

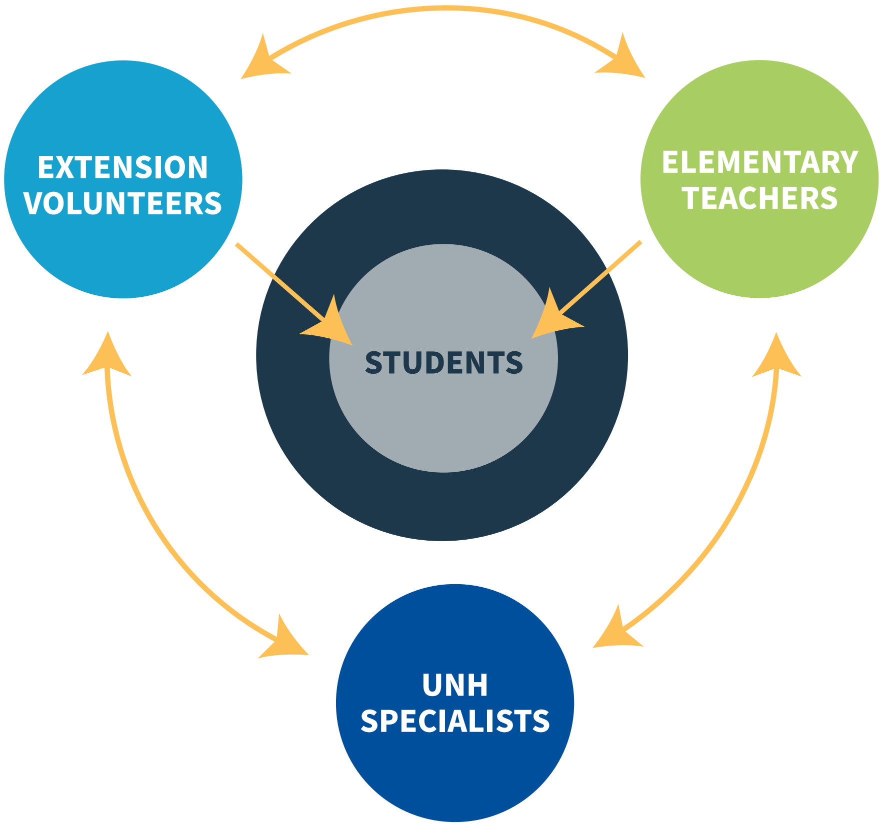


FIGURE 1: The Schoolyard SITES conceptual model illustrates a three-pronged collaboration among elementary teachers, Extension science volunteers, and university professional development and science professionals.

Collaborative Teams - Teachers & Volunteers

The Schoolyard SITES professional development model is a three-pronged collaboration among elementary teachers, Extension science volunteers, and professional development/science professionals. This three-way collaboration is central to building both content knowledge and teacher self-efficacy in Schoolyard SITES elementary teacher-participants. Our complementary pairing approach alleviates the need for project volunteers to have an initial high level of elementary instructional expertise, while at the same time providing scaffolding for the classroom teachers to become classroom "scientists" over time. The Collaborative Model (Figure 1) illustrates how teachers, volunteers, and professional development specialists create a synergy of skills, expertise, and content knowledge.

Building community partnerships for school-based science programs is difficult because not all community volunteers have the time, resources, and background

to volunteer in school-based programs. To address this need, we recruit Extension volunteers already trained by UNH Cooperative Extension in an area/topic of science. These New Hampshire-based Extension science volunteers include Master Gardeners, Marine Docents, STEM Docents, NH Coverts, and Natural Resource Stewards, all of whom express a strong commitment to the yearlong Schoolyard SITES program, including the workshop series and school year partnership with the teachers.

The Schoolyard SITES professional development workshop series emphasizes a collaborative learning approach that supports the development of a partnership between teachers and project volunteers. The professional development framework is structured such that elementary teachers will share their knowledge of instructional planning and pedagogy, while at the same time the volunteer shares their knowledge of specific, local life or Earth science topics and their passion for the scientific enterprise.

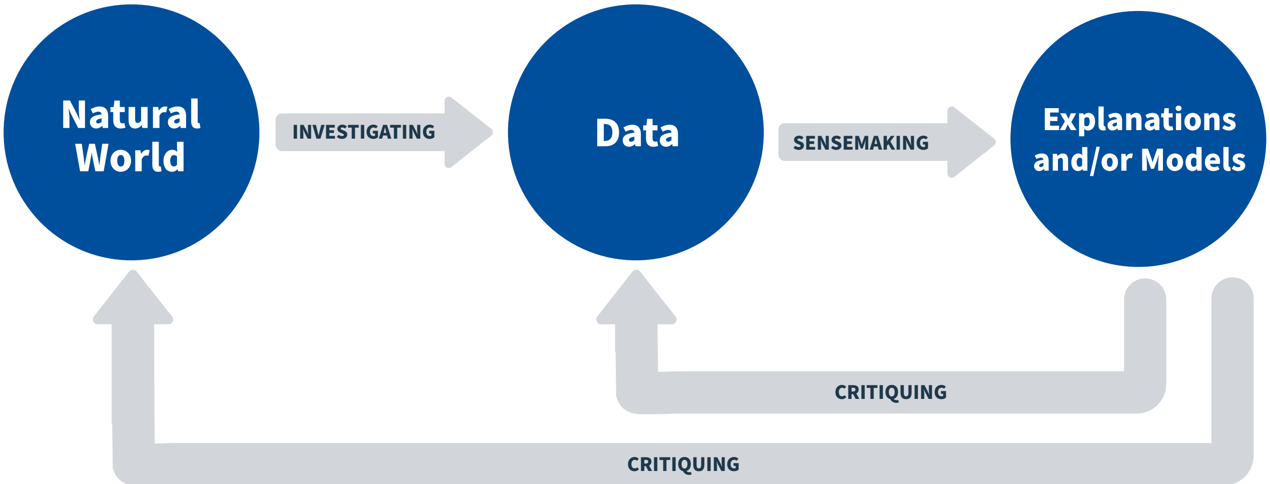
Applying NGSS Science Practices

The current vision of science education positions K-12 students as sense-makers and doers of science. To realize this contemporary vision, educators are challenged to engage their students with the eight NGSS science practices to investigate the world around them (Table 1).

There is extensive overlap between the NGSS science practices as students apply them. A useful way to conceive the eight practices and their interplay is put forth by McNeill et al. (2015), Figure 2. This conceptual model groups practices by three main categories: investigating; sense-making practices; and critiquing practices.

TABLE 1: Description of the Next Generation Science Standards Science Practices (NGSS Lead States 2013).

NGSS Science Practice		Description
1.	**Asking questions**	Raising questions about phenomenon, a claim, a model, or data.
2.	**Developing & using models**	Constructing conceptual representations that approximate the phenomena they represent. A model may be physical replicas, mathematical, visual, or computational.
3.	**Planning & carrying out investigations**	Designing an investigation that includes procedures to collect reliable data.
4.	**Analyzing & interpreting data**	Organizing evidence, bringing out the meaning of the data, and drawing a conclusion by assessing the data.
5.	**Using mathematics & computational thinking**	Using logic, numbers, and equations to describe and represent physical phenomena and using computer algorithms to analyze and represent complex phenomena.
6.	**Constructing explanations**	An explanation is an evidence-based account for phenomena. It includes a claim that relates how a variable(s) relate to other variable(s) and is supported by existing scientific ideas, principles, and theories.
7.	**Engaging in argument from evidence**	Using tentative evidence-based claims and reasoning to persuade and to establish or defend a new idea or explanation.
8.	**Obtaining, evaluating, & communicating information**	Recognizing reliable sources of scientific information and representing information orally, in writing, and using tables, graphs, models, and other visuals.



PRACTICES	Investigating Practices	Sensemaking Practices	Critiquing Practices
	☐ 1. Asking questions ☐ 3. Planning and carrying out investigations ☐ 5. Using mathematical and computational thinking	☐ 2. Developing and using models ☐ 4. Analyzing and Interpreting data ☐ 6. Constructing explanations	☐ 7. Engaging in argument from evidence ☐ 8. Obtaining, evaluating and communicating information

Figure 2: The relationship of the NGSS 8 science practices organized by type and showing the iterative nature of scientific research (reprinted with permission from McNeill, Katsh-Singer, & Pelletier 2015).

Citizen Science—What, How, Why?

The field of citizen science has yet to identify the exact criteria that describe citizen science. As a result, the definition of citizen science is still evolving and varies based on the activities and goals associated with a citizen science initiative (National Academy of Sciences 2018). Our project's definition of citizen science most closely aligns with Bonney (1996): "The process by which both professional and volunteer scientists collaborate to investigate the world around them."

Schoolyard SITES utilizes established citizen science programs (e.g., iNaturalist, GLOBE, Project FeederWatch, etc.) to support science learning in the elementary classroom. We identify two ways the teacher-volunteer teams can use citizen science to accomplish their educational goals for Schoolyard SITES:

1. Contribute to an existing citizen science project using a scientific question that aligns with NGSS and the citizen science project (e.g., what trees produce leaves first in the spring? & GLOBE's Green-Up).
2. Use existing datasets of locally relevant citizen science projects to study a natural phenomenon (e.g., third graders participated in CoCoRaHS and used previous precipitation data/records in their analysis).

While not all citizen science initiatives are designed to achieve specific learning outcomes, research indicates that citizen science can provide opportunities for science learning in K-12 classrooms when educators select the most relevant citizen science practices or modify projects to align with their learning goals (National Academy of Sciences 2018). The wide variation of citizen science projects helps the teacher-volunteer teams to select and incorporate appropriate citizen science platforms while maintaining a focus on educational outcomes and supporting science learning in the elementary classroom. In fact, the process by which teacher-volunteer teams select an appropriate citizen science platform addresses multiple considerations, including the expected learning outcomes (e.g., NGSS), school's location, the students' grade-level, and the particulars of the established citizen science project. To guide the teacher-volunteer team's selection process, we developed a tool, referred to as the Decision Cascade, which is described in detail in the section entitled Using the Decision Cascade (Figure 2).

When students engage in relevant citizen science projects, the following positive learning outcomes have been identified (National Academy of Sciences 2018):

- motivation and interest in learning science
- using scientific tools and participating in science practices
- learning specific scientific disciplinary content
- building an identity as a scientist
- scientific reasoning

We include citizen science as part of the Schoolyard SITES model for several reasons. First, citizen science projects are often locally relevant and place-based. Local science topics are motivating and pique interest in science for adults and children. Second, many citizen science projects provide established scientific protocols for collecting data. In this way, the citizen science project provides a structure for conducting a scientific investigation without supplying the expected scientific outcome, thereby supporting a more inquiry-based learning experience for students. Third, citizen science projects afford students the opportunity to contribute their data to a real-world science project. This aspect is motivating to the teacher-volunteer teams and students. In fact, the role of the volunteer often focuses on imparting knowledge of and navigating the use of the citizen science platform, all of which may help build the students' identity as a scientist. For more details about citizen science and selecting appropriate citizen science projects see Guide to Choosing Locally Relevant Citizen Science Projects for the Classroom. Be mindful that citizen science platforms can come and go with the availability of resources, however doesn't diminish their usefulness and shouldn't discourage one from incorporating them into a curriculum.

Project Planning Guide

To support the Schoolyard SITES teacher-volunteer teams with designing a relevant citizen science curriculum, we provide a Project Planning Guide (Appendix I). The Project Planning Guide incorporates the main steps and decision-making required early on, into a practical working guide to design the investigation and inform the new curriculum. As one's planning transitions from pedagogical decisions to classroom activities, the Project Planning Guide serves as an organizing and connecting document. In essence, it is a series of templates and worksheets that educators can use in developing their curriculum.

The main sections of this workbook directly correspond to the Project Planning Guide, thereby providing the user with a detailed description of the overall process for designing a citizen science curriculum. Throughout this workbook we refer to our project's complementary resource, Guide to Choosing Locally Relevant Citizen Science Projects for the Classroom, that provides specific guidance on identifying citizen science projects that fits your needs. Finally, we provide concrete examples, using a salamander citizen science investigation, to illustrate the multi-step, curriculum design process.

To learn more, dig in!

Using the Decision Cascade

In working to engage kids in science, we have observed a tendency by teachers to gravitate towards content that is personally interesting, particularly when given the opportunity to incorporate novel elements and resources into one's curriculum. However, when a piece of curriculum is designed without considering external factors such as standards and competencies, or location of the field site, it can prove difficult to sustain long term. The process and tools that follow represent a planning progression that will help educators build curriculum based on a hierarchy of both constraints and opportunities.

The Decision Cascade is a model that prioritizes steps of the development process, as well as the chronology of the accompanying professional development programming. In its practical application, it is a hierarchy of decisions for choosing a citizen science project topic around which learning activities are centered (Figure 3; for blank worksheet see Appendix II). If adhered to, the Decision Cascade will help create investigations that are engaging, provide data to the relevant citizen science program, and go beyond meeting the prescribed standards and competencies, promoting durable understanding of science practices, content, and concepts.

Curriculum Needs & School Competencies

As Next Generation Science Standards have gradually been incorporated, first by states, then districts, and finally by curriculum coordinators and teachers in individual schools, the niche projects that teachers might have previously taught on their own have increasingly fallen by the wayside. This means that external projects, such as Schoolyard SITES, need to directly align with NGSS and be developed in a way that they can mesh with an entire school's curriculum, both across grade-span and vertically. As such, these considerations need to be the top priority in your decision-making.

Characteristics of School Site & Timing of Implementation

The second tier in the Decision Cascade hierarchy addresses when and where the investigation will be conducted. Because Schoolyard SITES is focused on local, environmental investigations, the phenomena being investigated needs to be present in the location that it is being observed, and it must be observable during the timeframe that the curriculum is delivered to students. This can be a common limitation in northern latitudes, as many biological phenomena are best studied during specific times of year that don't line up with the academic calendar. Geographic location will also constrain which topics are available for place-based study. This can be a particular challenge for urban schools that may, at first glance, not have many options for study sites on, or near, the school grounds. This limitation, however, may offer opportunities for creative observation of natural or urban phenomena that may surprise teachers and students alike – such as urban birds, rainfall, or surface temperatures of different ground surfaces.

Choosing a Citizen Science Platform

This is the decision point that teams often gravitate toward immediately. To a large extent, the Decision Cascade was developed to combat the tendency to immediately search out exciting citizen science programs, and then become determined to make them work. By following the steps of the Decision Cascade (Figure 3), the resulting project will incorporate important standards and competencies, and avoid investigation frustrations such as too little data, weather problems, or too few opportunities for direct observation. As a complement to this step in the Decision Cascade, please refer to the Guide to Choosing Locally Relevant Citizen Science Projects for the Classroom.

Choosing a Project Topic

The final step in the process is to choose a project topic that will be the foundation for an investigation-based piece of curriculum. Although in some cases this step might be quite similar to that of choosing the citizen science platform, it differs subtly in that you will be framing, or refining, the goals and protocols of the citizen science platform to arrive at a topic that addresses your learning objectives.

Once completed, the components of the Decision Cascade will populate Step 1 of the Project Planning Guide (Appendix I). Figure 4 provides an example of applying the Decision Cascade to our team's salamander citizen science project in Durham, New Hampshire.

Curriculum Needs and School Competencies

What are the disciplinary core ideas (content), science practices and cross-cutting concepts that you need to teach?

Characteristics of School Site and Timing of Implementation

In what ways do the natural characteristics of your field site, combined with the seasonality of your project determine what types of phenomena and variables can be investigated?

Choosing a Citizen Science Platform

Is the citizen science platform cognitively appropriate for your students, or can it be modified and/or supplemented to meet the requisite learning goals?

Project Topic

Based on the factors above, what is an appropriate topic for the project? The topic will be the foundation for an investigation-based piece of curriculum.

FIGURE 3: Decision Cascade concept for selecting a project topic.

Step 1: Project Decision Cascade

Curriculum needs, relevant NGSS and/or school competencies	Characteristics of a school site, timing of implementation and phenomena present	Citizen Science Platform (which one; why)
• NGSS Performance Expectation: Construct an argument with evidence that some habitats support particular species. Biological Evolution: Unity and Diversity (3-LS4-3)	• University forest land - College Woods in Durham, New Hampshire • Summer - July • Red-backed salamander studies already underway in College Woods (UNH Natural Resources)	• SPARCNet: red-backed salamander monitoring program in New England • GLOBE Program: provide protocols for characterizing environmental conditions in the forest • iNaturalist: supports wildlife and plant identifications
Topic:		
Where red-backed salamanders live in College Woods (Durham, NH)		

FIGURE 4: Example Project Planning Guide - STEP 1 for the salamander project.

How to Identify Framing Questions & Citizen Science Connections

Once you select a topic using the Decision Cascade (Figure 3), the next phase of planning involves identifying the main questions that frame your citizen science curriculum and the students' scientific investigation. As with most science projects, questions about the phenomenon drive the overall investigation design and the procedures used by students when carrying out the investigation.

Revisit NGSS Performance Expectation & Identify Target Learning Outcomes

To start, revisit the big ideas and NGSS expectations that you selected for your Decision Cascade. Using the Project Planning Guide (Figure 7; see Step 2-Outcomes) name the NGSS Performance Expectation(s) or other school-based content standard(s) on which your curriculum will focus.

As with your topic selection earlier, the NGSS Performance Expectation(s) or other standard(s) influence all parts of your curriculum. Next, describe the desired learning outcomes, by listing the key understandings and NGSS science practices that will be emphasized and on which students will be assessed.

You likely are asking yourself: to what extent are my students involved in asking the scientific questions or the other NGSS science practices? The degree to which the students lead the development of the scientific question (NGSS Science Practice #1) or engage in any of the NGSS science practices depends on several factors and ultimately is your choice as an educator. To aid in your planning for the citizen science curriculum, refer to the Educator-Learner Responsibility Chart (Appendix IV) to select the level of responsibility that fits your students' and your desired learning outcomes.

Designing the Overarching Essential Question for the Curriculum

Teachers with prior experience designing curriculum units are likely familiar with constructing essential questions. Essential questions are overarching and broadly apply to the curriculum topic. Commonly, the teacher and students revisit this essential question throughout the investigation, thereby helping to focus the science learning.

One way to create your essential question is to simply rephrase the topic in the form of a question. The Decision Cascade with Framing Questions example (Figure 5) illustrates this part of the planning process. Notice how the contents of the Decision Cascade impact the wording of the essential question. The essential question is identified before the testable scientific questions are generated.

Developing Essential & Testable Questions

Curriculum Needs and School Competencies

Construct an argument with evidence that some habitats support a particular species (3-LS4-3 Biological Evolution: Unity and Diversity)

Characteristics of School Site, Phenomena Present and Timing of Implementation

Forested area - July

Choosing a Citizen Science Platform

Canopy cover by GLOBE & salamander monitoring by SPARCNet

Project Topic

Where salamanders live in College Woods

Essential Question

What kinds of habitat do red-backed salamanders live in?

Scientific Question

Develop a testable question

FIGURE 5: Decision Cascade with framing questions included.

Developing & Identifying Testable Scientific Questions

In contrast to the essential question, the testable scientific questions are even more specific and directly inform how students carry out the investigation. In other words, the testable questions are the scientific questions driving your students' investigation procedures (i.e., protocols). "Scientific questions are distinguished from other types of questions in that the answers lie in explanations supported by empirical evidence, including evidence gathered by others or through investigation" (NGSS Lead States 2013, Appendix F, p. 4).

How do we arrive at testable, scientific questions? For field-based topics, such as those generated in the schoolyard, conducting observations of the phenomena is a very effective way to develop initial questions about your topic. Other ways you can generate ideas for testable questions include utilizing questions already identified by the citizen science platform itself (see Guide to Choosing Locally Relevant Citizen Science Projects for the Classroom), searches on the web, and video or print resource explorations.

Field notebooks are a valuable tool with which students can observe the study site and generate preliminary ideas. Field notebook entries include labeled drawings, detailed descriptions, and ultimately a list of potential questions that relate to the phenomenon and topic. The Science Notebook: Developing Scientific Questions worksheet (Appendix III) suggests prompts for you and your students to refer to in the field and to help with the development of initial questions.

Once you and your students have a collection of questions, it is likely that a subset of these are useable and will fit the criteria for scientific questions. Use the Sorting Question Tool (Figure 6) to select the most appropriate testable question or questions. To best accomplish this, teachers might find it useful to write individual questions on index cards or Post-it Notes and then physically sort all the questions based on the Sorting Question Tool criteria into two main categories: testable and non-testable questions.

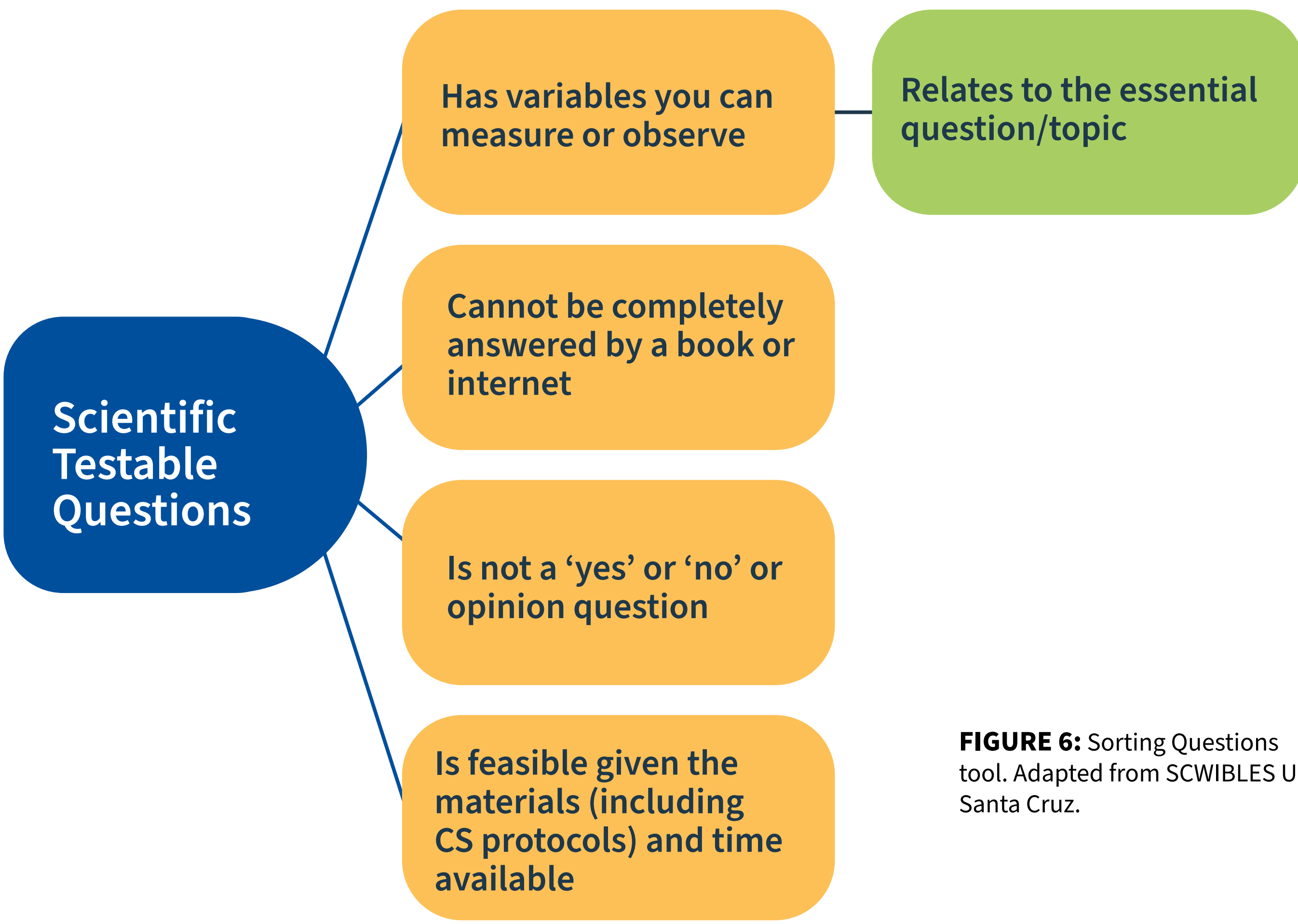


FIGURE 6: Sorting Questions tool. Adapted from SCWIBLES UC Santa Cruz.

As a result of a field observation and the use of the Sorting Question Tool, the following testable questions are identified for the salamander example project:

- What is the relationship between the temperature of the soil and the number of salamanders present?
- What is the relationship between the tree canopy coverage and the number of salamanders present?
- What is the relationship between the distance from the walking path and the number of salamanders present?
- What is the relationship between the type of leaf litter present (coniferous needles or deciduous leaves) and the number of salamanders present?

Once you have generated some testable questions record them in your Planning Guide-Step 2 (Figure 7).

Step 2: Framing Questions & Learning Outcomes		
Performance Expectation	Construct an argument with evidence that some habitats support particular species. Biological Evolution: Unity and Diversity (3-LS4-3)	
Essential/Topic Question	What kinds of habitat do red-backed salamanders live in?	
Testable Scientific Question	• What is the relationship between the temperature of the soil and the number of salamanders present? • What is the relationship between the tree canopy coverage and the number of salamanders present? • What is the relationship between the distance from the walking path and the number of salamanders present? • What is the relationship between the type of leaf litter present (coniferous needles or deciduous leaves) and the number of salamanders present?	
Desired Learning Outcomes (this informs the assessment)		**Citizen Science Project Connection** *What is the science question driving the CS platform? How will it be incorporated to support the learning outcomes?*
Understandings (What are the big ideas?)	*Key science practices (at least one practice from each of the 3 categories: investigating, sensemaking, & critiquing)*	
Organisms respond to a variety of conditions in their environment Some environmental conditions (habitats) support particular species	• Asking Questions (#1) • Planning and Carrying out Investigations (#3) • Analyzing and Interpreting Data (#4) • Engaging in Argument from Evidence (#7)	SPARCNet's Question: What are the effects of climate change and land use on salamander populations? SPARCNet (salamander population monitoring, cover board plot field method) GLOBE (canopy cover-protocol use) iNaturalist (field-based species documentation-species identification support)

FIGURE 7: Example Project Planning Guide-STEP 2 for the salamander project.

Citizen Science Connections

Again, revisit your original Decision Cascade and the citizen science platform(s) selected. It's time to further consider and identify how the citizen science platform(s) will be incorporated into the curriculum. Each platform differs and the nature of the platform will dictate the way it is embedded into your curriculum. Most importantly, as you make these decisions make sure you are aligning with the desired learning outcomes (Figure 7; see Project Planning Guide-Step 2-Outcomes).

Some common ways a citizen science platform can be incorporated and used by educators to support learning outcomes:

1. By providing a testable scientific question or ideas for students to design their own scientific questions;
2. By providing a detailed data collection protocol, including user-friendly data sheets or online data submission forms;
3. By enhancing the data analysis by providing additional data — either data over time or space — that can be compared to the students' local, schoolyard data;
4. By offering a web platform to upload the students' data to be shared with research scientists and contribute to the broader citizen science initiative.

For more suggestions, refer to our project's complementary resource, Guide to Choosing Locally Relevant Citizen Science Projects for the Classroom, which provides specific guidance on identifying citizen science projects that fits your needs.

In our example salamander investigation, we use several citizen science platforms: SPARCNet, the GLOBE Program and iNaturalist. SPARCNet is the main citizen science platform that dictates the topic, informs the scientific questions, and provides a field protocol for measuring the salamander population in a local forest. The GLOBE Program offers a specific field protocol to measure forest canopy cover in relation to salamander monitoring. iNaturalist provides a field-based plant identification tool and means to document tree species found in our study area (Figure 7).

Planning the Scientific Procedure & Data Usage

It is critical to design the scientific procedures during your planning process. To start, ascertain the best study area within your location. This may involve scouting, sometimes even mapping, the location and doing some preliminary observations to ensure the site works for your project. In addition, you will identify the specific time of year the students will carry out the citizen science project. You also need to anticipate the data collection, required equipment, and locate the appropriate scientific protocols for your students' use.

In many cases the citizen science platform provides specific protocols to collect appropriate observations and measurements, including user-friendly data collection tables or forms (see Guide to Choosing Locally Relevant Citizen Science Projects for the Classroom). If established protocols are not available, you can work with appropriate experts (for Schoolyard SITES this means our Extension volunteers) to locate or develop protocols for your investigation.

In general, citizen science platforms offer the opportunity for data to be shared with other scientists, including research scientists who lead the citizen science initiative. As part of your planning, determine how you and the students will interface with the citizen science platform with respect to uploading class data.

While planning the salamander investigation, we learned of a University of New Hampshire lab that already studies salamanders in our local research forest. We used their existing field set-up (i.e., cover boards) because it matched the protocols suggested by the SPARCNet citizen science platform. We shared our data collection with both the university lab and SPARCNet.

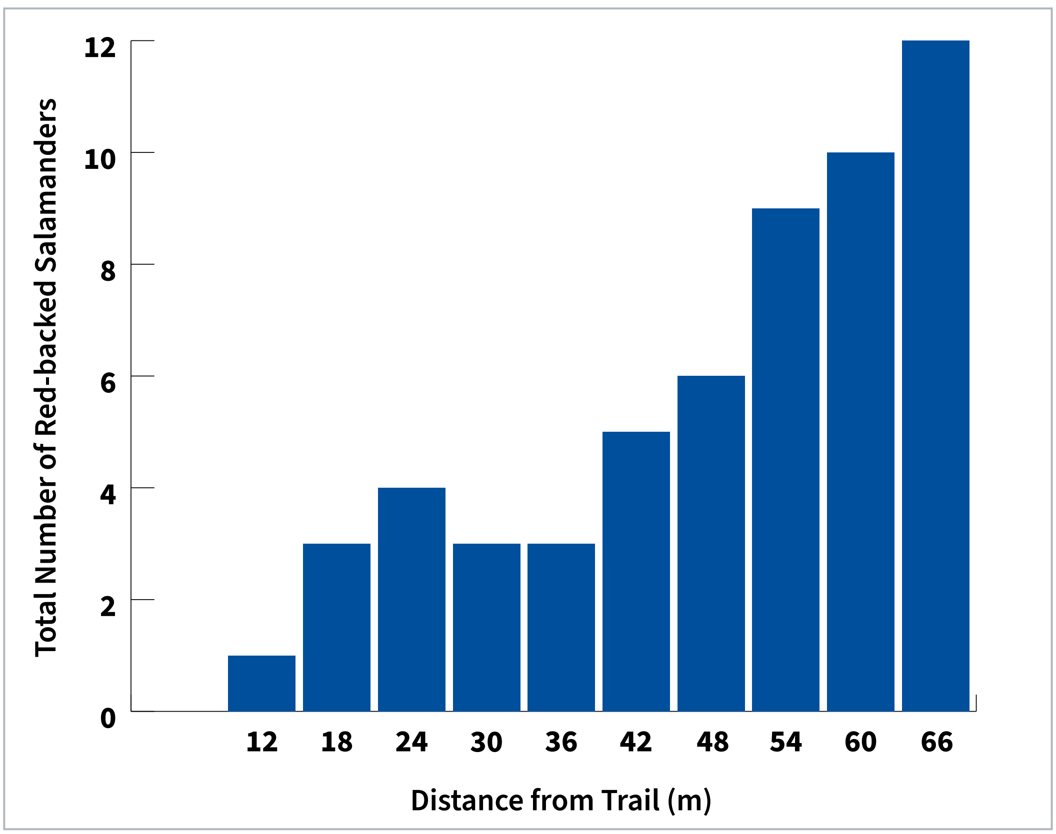
How do you expect the students to make sense of the data? It's not too early to consider the anticipated data analysis for your data collection. Sketch various options for data visualizations (e.g., charts, diagrams, graphs) (Figure 8). By considering data analysis early (NGSS Practice # 4), you will identify even more opportunities for engaging students' mathematical and computational thinking (NGSS Practice # 5) in a grade-level appropriate manner.

Distance from Trail (m)	Number of Salamanders
12	1
18	3
24	4
30	3
36	3
42	5
48	6
54	9
60	10
66	12

A. Example Data Table

Distance from Trail (m)	Number of Salamanders
12	I
18	III
24	IIII
30	III
36	III
42	𝍸
48	𝍸 I
54	𝍸 IIII
60	𝍸 𝍸
66	𝍸 𝍸 II

B. Example Tally Chart



C. Example Bar Graph

FIGURE 8: Example data set and types of data displays that may be used as part of the data analysis and interpretation. Salamander data courtesy of Dr. Purrenhage at UNH.

As you finalize your ideas for the procedure and data usage, populate the fields in Planning Guide-STEP 3. For an example based on the salamander investigation, see Figure 9.

It's also important to consider to what extent the students will be involved in the planning of the investigation (NGSS Science Practice #3). Refer to the Educator-Learner Responsibility Chart (Appendix IV) to select the level of responsibility that fits your students and your learning objectives. The Investigation Plan Worksheet (Appendix V) is intended to support your facilitation of your students' planning of the scientific procedure.

Step 3: Planning the Procedure & Data Usage		
Study Site *Describe the field location*	**Time of Year** *Describe the season, month, year*	**Data Collection** *List variables you will observe and/or measure*
Local forest-College Woods in Durham, New Hampshire (Dr. Purrenhage study site)	Summer July	Independent Variables: • Forest canopy cover • Soil temperature • Type of leaf litter • Distance from trail Dependent Variable: • # of red-backed salamanders
Required Materials *List materials you will need; approximate how much equipment is necessary for a class*	**Protocols** *What are the step-by-step activities to carry out the investigation? How will data be recorded?*	**Anticipated Data Analysis & Sharing** *Describe the data visualizations and necessary calculations; Will you share data with others, including uploading data to a citizen science platform?*
• Field notebooks & pencils (20) • Cover boards (use existing set-up in College Woods) • Soil thermometers (4) • Densiometers (4) • Amphibian field guide • Clipboards (4) • Wind scale reference (4)	• SPARCNet's terrestrial salamander monitoring cover board method (data codes & sheet included) • GLOBE Program's Biosphere protocol for tree canopy and ground cover (data sheet included) • iNaturalist (for species identification)	Series of bar graphs illustrating total # of salamanders at (1) varying distances from the path, (2) associated with varying canopy cover, (3) in coniferous vs. deciduous leaf litter areas, and (4) at differing soil temperatures Share results with SPARCNet researchers & Purrenhage Lab

FIGURE 9: Example Project Planning Guide-STEP 3 for the salamander project.

Considerations for Carrying Out Investigations in the Schoolyard/Field

It is exciting for students to carry out science outside of their classroom and explore natural phenomena in their own communities. To make the most of using the outdoors when teaching science, we recommend planning the logistics ahead of time.

Fieldwork Checklist

Use the following checklist and Project Planning Guide-STEP 4 (Figure 10) to further prepare for a successful outdoor learning experience for you and your students.

- ☐ Where is your study location (e.g., specific boundaries)?
- ☐ Would it help your students' experience to have a map of the area?
- ☐ Do you need permission to access the site?
- ☐ Do you need to provide transportation for the students?
- ☐ What scientific equipment is required?
- ☐ How do you expect to group students in the field?
- ☐ How much equipment will be sufficient for your class size/student groupings and desired learning outcomes?
- ☐ What are the requirements and safety considerations for setting up/using the field equipment?
- ☐ What are the safety considerations for bringing your students outdoors? What norms will you establish (e.g., stay with a partner, stay within boundaries, respect living things)?
- ☐ What's the approximate timeline for the preparation & implementation phases of your project?
- ☐ Who is involved (e.g., community volunteers, other staff, parents) in supporting the students' investigation? What are the roles and responsibilities of each of the adults?

Given students' limited experience learning outdoors you may want to consider some shorter, focused activities to practice being outdoors and following the established norms. For example, give them an opportunity to draw a site map in a field notebook or practice a part of the protocol with a partner. Each time you bring the students to the field site they build their skills and confidence conducting science outdoors.

For a complete example of Planning Guide-STEP 4 for the salamander investigation see Figure 10.

Step 4: Project Safety & Logistics		
Requirements *Safety and school site access (if any)*	**Timeline** *Sequence of events and appropriate dates*	**Team member roles and responsibilities** *Planning, preparation, implementation*
• Notify students about the 15-minute walk to the study site ahead of time; ask if they have concerns or require accommodations (we could drive closer to the site for some individuals) • Scout study area with Dr. Purrenhage to locate her lab's cover board array; look for any hazards (i.e., poison ivy) • Review map of the study site	1. April-Gather protocols and equipment 2. May-Review the protocols, including equipment with the instructors 3. May-Divvy up roles for carrying out the investigation in the field 4. June-Visit the field site with all instructors and finalize the overall procedures and individual's roles 5. June-Consider rainy day scenarios and how to carry out the investigation if weather is not conducive to data collection 6. June-Prepare field bags, data sheets per group (total of 4 groups) 7. July-Carry out investigation (4 groups with UNH instructors per group) 8. July-Analyze and interpret data; construct tentative claims/ arguments based on evidence	Project Director: oversee project administrative duties & investigation design; work with the leadership team to co-design & deliver all activities; assess outcomes & make modifications for future Project Manager: send communications to teacher & volunteer participants; order field equipment; help prepare materials; document participants' responses & collect evaluations Project Staff/Instructors: prepare for & facilitate the fieldwork and other workshop activities; review participants' input/responses and evaluate outcomes to make modifications for future workshops Teachers and Volunteers: actively participate in the overall experience and reflect on the instructional approaches used that apply to their own citizen science curriculum projects

FIGURE 10: Example Project Planning Guide-STEP 4 for the salamander project.

Planning the Scope & Sequence of the Learning Activities

You are ready to design the entire sequence of learning activities (i.e., lessons) to achieve your desired learning outcomes (Figure 11). As you commit to a sequence of lessons, refer to all previous steps in the guide to ensure you are honoring earlier decisions and the broader vision for your citizen science curriculum.

Step 5: Scope & Sequence of Learning Activities			
Lesson #	**Topic for Learning Activities** *What experiences will enable students to achieve the desired learning outcomes?*	**NGSS Science Practice** *Which of the 8 NGSS practices will be embedded?*	**Notes** *Team member roles & responsibilities, logistics*
1	Field Notebook Observation & Introduce Citizen Science Topic	SEP3-Planning & Carrying Out Investigations	
2	Identify Common Local Salamanders	SEP3-Planning & Carrying Out Investigations	
3	Practice Field Protocol (GLOBE's ground & canopy cover; soil temp; salamander cover board method)	SEP3-Planning & Carrying Out Investigations	
4	Create Testable Questions	SEP1-Asking Questions	
5	Understanding the Investigation	SEP3-Planning & Carrying Out Investigations	
6	Analyzing Data	SEP4-Analyzing & Interpreting Data	
7	Interpreting Data	SEP4-Analyzing & Interpreting Data	
8	Drawing Conclusions from Data	SEP6-Constructing Explanations SEP7-Engaging in Argument from Evidence	
9	Preparing Presentations	SEP8-Obtaining, Evaluating, & Communicating Information	
10	Final Presentations	SEP8-Obtaining, Evaluating, & Communicating Information	

FIGURE 11: Example Project Planning Guide-STEP 5 for the salamander project.

Writing the Curriculum Unit

The Curriculum Unit and Lesson Planning Template is based on the premise that, as teachers, you are the ones best positioned, and most appropriate, to develop curriculum for your students. You are the ones who understand the specific ways in which standards and competencies have been adopted and adapted and also best understand the larger context in which the learning will take place. This unique perspective allows you to create a learning continuum that will help students to construct deeper and more durable knowledge.

It is important that you have the opportunity, if desired, to use your own unit and lesson planning format so that your focus is less on the nuts and bolts of what a curriculum plan looks like and more about the incorporation of specific learning goals within it. However, because aspects of conducting this type of investigation are entirely new to many teachers, you may find it a struggle to incorporate all aspects of a new curriculum into your existing format.

The Schoolyard SITES Unit and Lesson Planning Template (Appendix VI) maintains a somewhat generic, and likely familiar, format while also incorporating novel elements of the project, and closely mirrors the professional development model that it accompanies. As with the other parts of this workbook, every section in the Unit/Lesson Template can, at least partially, be populated by transferring material from one of the previous worksheets (e.g. Decision Cascade-Appendix II) or notes from the preceding use of the Project Planning Guide (Appendix I). Finally, as with many of the other worksheets/templates, there is a guidance version to accompany the blank unit/lesson template (Appendix VII).

Final Thoughts

We hope you find this Workbook relevant and useful as you plan outdoor science learning experiences for your students. These guides are meant to be used flexibly as each classroom community will demand different kinds of supports and resources. Teachers' knowledge of their students and their specific needs will inevitably drive project implementation.

Works Cited

Bennett, K. (2010). Citizen scientists: fifth graders work as researchers on the hunt for an invasive species. *Science and Children*, 48(1), 50-53.

Bouillion, L. M., & Gomez, L. M. (2001). Connecting school and community with science learning: real world problems and school–community partnerships as contextual scaffolds. *Journal of research in science teaching*, 38(8), 878-898.

Honwad, S., Koper, M., Abrams, E., Middleton, M. (2015). *Designing a community-based student interest-focused sustainability science curriculum*. American Educational Research Association's annual conference, Chicago, IL.

Houseal, A.K., Abd-El-Khalick, F., & Destefano, L. (2014). Impact of a student-teacher-scientist partnership on students' and teachers' content knowledge, attitudes toward science, and pedagogical practices. *Journal of Research in Science Teaching*, 51(1), 84-115.

McNeill, K. K., R. Katsh-Singer, and P. Pelletier. (2015). Assessing science practices: Moving your class along a continuum. *Science Scope 39* (4): 21-28.

Miller, R.G., Curwen, M.S., White-Smith, K.A., & Calfee, R.C. (2015). Cultivating primary students' scientific thinking through sustained teacher professional development. *Early Childhood Education Journal*, 43: 317-326.

National Academies of Sciences, Engineering, and Medicine. (2018). Learning through Citizen Science: Enhancing Opportunities by Design. Washington, DC: The National Academies Press.

National Research Council. (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas*. Washington, D.C.: The National Academies Press.

National Research Council. (2000). *Inquiry and the national science education standards*. Washington, D.C.: The National Academies Press.

National Research Council. (1996). *National science education standards*. Washington, D.C.: National Academy Press.

NGSS Lead States. (2013). *Next generation science standards: For states, by states*. Washington, D.C.: The National Academies Press.

Paige, K., Lloyd, D., Zeegers, Y., Roetman, P., Daniels, C., Hoekman, B., Linnell, L., George, A., Szilassy, D. (2012). Connecting teachers and students to the natural world through Operation Spider: an aspirations citizen science project. *Teaching Science*, 58 (1), 13-20.

Plumley, C. L. (2019). 2018 NSSME+: Status of elementary school science. Chapel Hill, NC: Horizon Research, Inc.

Trautmann, N.M., Shirk, J.L., Fee, J., & Krasny, M.E. (2012). Who poses the question? Using citizen science to help K-12 teachers meet the mandate for inquiry. In J.L. Dickinson & R. Bonney (Eds.), Citizen science: Public participation in environmental research (179-190). Ithaca, NY: Cornell University Press.

Watters, J. J., & Ginns, I. S. (2000). Developing motivation to teach elementary science: Effect of collaborative and authentic learning practices in preservice education. *Journal of Science Teacher Education*, 11(4), 301-321.

Appendices

Appendix I: Project Planning Guide

Step 1: Project Decision Cascade

Curriculum needs, relevant NGSS and/or school competencies	Characteristics of a school site, timing of implementation and phenomena present	Citizen Science Platform (which one; why)

Topic

Step 2: Framing Questions & Learning Outcomes

Performance Expectation	
Essential/Topic Question	
Testable Scientific Question	

Desired Learning Outcomes (this informs the assessment)		**Citizen Science Project Connection** *What is the science question driving the CS platform? How will it be incorporated to support the learning outcomes?*
Understandings (What are the big ideas?)	*Key science practices (at least one practice from each of the 3 categories: investigating, sensemaking, & critiquing)*	

Step 3: Planning the Procedure & Data Usage

Study Site Describe the field location	**Time of Year** *Describe the season, month, year*	**Data Collection** *List variables you will observe and/or measure*
Required Materials *List materials you will need; approximate how much equipment is necessary for a class*	**Protocols** *What are the step-by-step activities to carry out the investigation? How will data be recorded?*	**Anticipated Data Analysis & Sharing** *Describe the data visualizations and necessary calculations; Will you share data with others, including uploading data to a citizen science platform?*

Step 4: Project Safety & Logistics

Requirements *Safety and school site access (if any)*	**Timeline** *Sequence of events and appropriate dates*	**Team member roles and responsibilities** *Planning, preparation, implementation*

Step 5: Scope & Sequence of Learning Activities

Lesson #	**Topic for Learning Activities** *What experiences will enable students to achieve the desired learning outcomes?*	**NGSS Science Practice**	**Notes** *Team member roles & responsibilities, logistics*
1			
2			
3			
4			
5			

Step 5: Scope & Sequence of Learning Activities - continued

Lesson #	**Topic for Learning Activities** *What experiences will enable students to achieve the desired learning outcomes?*	**NGSS Science Practice**	**Notes** *Team member roles & responsibilities, logistics*
6			
7			
8			
9			
10			

Appendix II: Decision Cascade

Curriculum Needs and School Competencies

Characteristics of School Site and Timing of Implementation

Choosing a Citizen Science Platform

Project Topic

Observation Guide - *Developing Scientific Questions*

Topic
Where salamanders live in College Woods

Essential Question
What factors influence where red-backed salamanders live?

Site Description
Describe the study site in detail, including any biotic or abiotic factors that you think might influence the study, and lead to the development of a testable question.

Diagrams
Make sketches and/or maps that will help inform your question development. This is the best way to capture spatial variation in the field site—where do those biotic (living) and abiotic (non-living) factors that you have described occur?

Data Collection Ideas
How would you measure (quantify) potential variables within your field site?

Feasibility
How might limitations of the field site, available tools/instruments, or amount of time affect the potential investigation?

Potential Questions
Based on the information that you have collected for your science notebook, develop 3-5 potential questions about salamanders and their habitat for us to investigate. Consider whether these questions are testable.

Appendix IV: Educator-Learner Responsibility Chart

Who is responsible for the question?

Educator Responsibility ←→ Learner Responsibility

Who is responsible for planning and carrying out the investigation?

Educator Responsibility ←→ Learner Responsibility

Who is responsible for the analysis and interpretation of the data?

Educator Responsibility ←→ Learner Responsibility

Who is responsible for the explanations and/or arguments?

Educator Responsibility ←→ Learner Responsibility

Who is responsible for communicating the information?

Educator Responsibility ←→ Learner Responsibility

Based on National Research Council (2000)
Inquiry & National Science Education Standards

Appendix V: Investigation Plan

Scientists **Date**

Testable Scientific Question

What do you want to find out? In your own words, describe the testable question that the investigation seeks to answer.

Design

Study Site

Describe the field location.

Time of Year:

Describe the season, month, year.

Variables:

Name the variables that you will observe and/or measure.

Materials Needed

Procedure

What are the step-by-step activities? Protocols? How will data be recorded? What calculations are needed for analysis?

Appendix VI: Schoolyard SITES Unit & Lesson Guidance Document

(*curriculum unit only)

Unit Title*

Descriptive name for curriculum unit.

Essential Question for Unit*

The topic question framing the curriculum unit.

Testable Science Question/s for Unit*

In some cases, this may be a single question for the entire class, or it could also be multiple questions asked by groups or individual students. Testable science questions: 1. Have variables that can be measured or observed; 2. Cannot be completely answered by a book or Internet; 3. Are not a 'yes' or 'no' or opinion question; 4. Are feasible given the materials and time available; and 5. Relates to essential question/topic.

Citizen Science Connection/s for Unit*

In addition to the citizen science platform being used, this would be a good place to include specific protocols or other external investigation resources.

Role of Extension Volunteer in Unit*

Provide a summary of the Extension volunteer's involvement overall and specifically the volunteer's anticipated role during the teaching of the lessons.

Next Generation Science Standards Addressed in Unit*

Include numbering schema from NGSS, if helpful. Likewise, if there is a school/district curriculum guide that you need to integrate, you should create different table here.

Disciplinary Core Ideas	Science and/or Engineering Practices	Crosscutting Concepts

Lesson Title or #

Time Frame

An estimate in hours/minutes for the lesson.

Educator and Learner Responsibility

This can be described here, in a narrative format, placed on the Educator & Learner Responsibility Level Chart, or, ideally, both.

Learning Goals

What will students be able to do during the lesson? This can take the form of a list of measurable actions and should directly connect to the assessment being used (below).

Assessment:

List the summative assessment and/or the formative assessments. Include criteria used to evaluate students' learning outcomes based on the stated learning goals and/or rubric, if available.

Equipment/Materials

Comprehensive list

Outlines of Events/Procedure

Give a numbered step-by-step suggested procedure that also includes the roles of any adults. Ideally, this will provide enough detail for another teacher to follow. It is often beneficial to include the pre- and post-lesson procedures as well. This might include the necessary teacher preparation, use of citizen the science platform when applied, and the final wrap-up of the individual lesson, including the kinds of formative or informal assessment used throughout the procedure.

Depending on the level of complexity, you may want to break this into sub-components, particularly if you have multiple student groups, or adults, doing different things.

External Curriculum Resources

List any other lesson plans, activities, data collection material, online resources, etc., and acknowledge and cite sources and/or the nature of collaboration.

Suggestions for Differentiation

Describe the ways that the lesson accommodates different learning modalities, special education students, and multilingual students. This is also a good place to document specific accommodations that meet the requirements of students' IEPs.

POST TEACHING REFLECTION*

Student Work

Describe a few examples of student work as a result of the unit — include the nature of student responses. You can also include student work.

Summary of Students' Performance

Final results of summative assessments.

Adjustments to the Unit for the Future

Appendix VII: Schoolyard SITES Unit & Lesson Template

(*curriculum unit only)

Unit Title*

Essential Question for Unit*

Testable Science Question/s for Unit
*(may be teacher or learner-driven)**

Citizen Science Connection/s for Unit*

Role of Extension Volunteer in Unit*

Next Generation Science Standards Addressed in Unit*

Disciplinary Core Ideas	Science and/or Engineering Practices	Crosscutting Concepts

Lesson Title or #

Time Frame

Educator and Learner Responsibility

Educator Responsibility ⟷ Learner Responsibility

Learning Goals

Assessment

Equipment/Materials

Outlines of Events/Procedure

Outlines of Events/Procedure (Continued)

External Curriculum Resources

Suggestions for Differentiation

POST TEACHING REFLECTION*

Student Work

Summary of Students' Performance during Unit

Adjustments to the Unit for the Future

