Concrete Questions: Restoring Our Land and Water

A California Coastal Voices Student-Driven Project

Restoration volunteers at Upper Newport Bay

Challenging Question:

How can we use science, policy, and nature-based engineering practices for ecological restoration in California?

For this Project:

Teacher Guide: Ecological Restoration

Ecological restoration is an evolving field, and as such, its definition is debated. One definition of ecological restoration is an intentional activity that pilots a damaged site towards sustainable ecological function. Restoration is not a substitute for preservation. It may not be possible to replicate historic functions and values, and the activities of ecological restoration—disking soil, using chemicals to remove exotics, irrigating—can further strain an already stressed ecosystem. However in many situations, ecological restoration can improve habitat value and ecosystem functions. Ecological restoration is also valuable for the links it forms between humans and nature, building a long-term commitment between a natural place and the community that surrounds it.

Photo: Central Coast Natural History Association

Climate change introduces new complications into restoration planning. How do you restore a wetland when the sea level is rising, or a riparian corridor when spring snowmelt and precipitation patterns are changing? In order to plan intelligently for restoration projects, climate change predictions must be understood and incorporated.

In this project, students will address the Challenging Question by analyzing a variety of self-selected data sources before designing, evaluating, and refining a quantitative solution for reducing the impact of human activity on the physical environment and restoring biodiversity at a site. Students will develop a restoration plan and will present it to a public audience. Students will do this work in teams, assuming the role of scientist, engineer, policy analyst, or principal investigator for their group. The rest of this document provides guidance to teachers in facilitating this work.

The student reading titled *Guide to Volunteer Restoration Field Work* assists students in connecting with a local organization or government agency to participate in a real-life restoration project. Although it is possible to omit the field experience, there is great educational value in getting students outside to experience what the work they are studying looks like and how it gets done in their community. Ideally this volunteer work involves habitat restoration and informs the student's final project, but depending on what is available locally it may be as simple as a shoreline cleanup. Either way, the student will be engaging in the important, hands-on work of restoring the natural environment.

Teacher Preparation Tasks:

- Review the *Teacher Checklist for Student-Driven Projects*, found in the "Readings and Resources" section. Review suggestions for Personalized Learning Plans and Group Contracts and decide if or how you will use these with your students.

- Review all student readings and handouts, listed on this project's cover sheet. Make copies for students as needed, or share electronically.

- Study the questions and links in this *Teacher Guide*. Refer back to the Teacher Support Pieces in *California Coastal Voices* as needed.

- Arrange a guest speaker to kick off the project. Options include a restoration ecologist, land manager, planner, or volunteer organizer involved in a local restoration effort.

- Identify and arrange for professionals and decision-makers who will serve as an audience for the students' public presentations. These might be land managers, local planners, elected officials, parents, or other adults.

- Consider what local habitat restoration efforts are available for the student volunteer field experience and whether you will assign locations and partner organizations, provide a list of choices, or have teams identify a site on their own.

- Research safety procedures and necessary permissions for the student field experience. Plan to arrange for or assist with any needed supplies such as sunscreen, extra jackets, work shoes, and transportation.

- For use in your classroom, choose Daily Phenomena from the Thematic Slideshows of Coastal Images available on the *Coastal Voices Website*, www.coastal.ca.gov/coastalvoices, or compile your own selection.

- Consider what type of guidance you want to give students in identifying a site for their group restoration planning project. Some possible options you might offer include:

  - Research a coastal location using existing habitat studies and photos in order to develop a plan for a site you're not able to visit.

  - Get out in your neighborhood and identify a local site that would benefit from restoration. Incorporate in-person observations and measurements. You might look for public open spaces that are accessible but degraded or not well-used, or for public walking trails with adjacent natural lands. Creeks, ponds, and parks are among the possibilities.

  - Look for a map of creeks that have been culverted under streets. Is there a location that might be appropriate for creek "day-lighting?"

  - Create a restoration plan for an area on your school grounds (which might involve removing pavement).

  - Identify an existing restoration project and develop a plan that extends or improves on the project.

- If you choose to identify potential restoration sites yourself, check in with the agencies that manage these lands. (Look for signage or do an internet search.) Creating this relationship may make visiting the site easier, expand the reach of the students' projects, and set the stage for the public audience for their presentation.

To act intelligently, restoration ecologists must have a significant body of discipline-specific knowledge from biology, ecology, and earth science. Consider exploring the following questions with your students as they develop a restoration plan. The following questions are guides to help you prepare to support student questioning and learning. While not anticipating every place a student may go, the questions provide connections to significant content related *Next Generation Science Standards* performance expectations (NGSS PEs) and disciplinary core ideas (NGSS DCIs), and to *California's Environmental Principles and Concepts* (EP&Cs). Your role is to facilitate the process through which students find their own way to many of these and similar questions. One strategy is to have one student from each group of four investigate one of the questions and report out to the group. Another strategy is to support the students in finding their own way to these or similar questions.

> Visit the *Coastal Voices Website* for links to resources that help answer these questions and to the full text of California's Environmental Principles and Concepts. You will also find images for download, links to videos, park brochures, and teaching resources.
>
> **www.coastal.ca.gov/coastalvoices**

Week One and Two:

- What types of interdependent relationships exist between nonliving and living components of ecosystems? (NGSS DCIs: ESS2.E and LS2.A)

- What are three key measures of biodiversity in ecosystems? (NGSS DCI: LS4.D)

- How do habitat fragmentation, water pollution, and climate change impact biodiversity at a restoration site? (NGSS DCIs: ESS3.C and LS2.C)

- How does habitat fragmentation, water pollution, and climate change impact the ability of an ecosystem to provide ecosystem services to human communities? (NGSS DCI: LS2.C; EP&Cs I)

- What types of cycles exist within natural systems linking the non-living and living components of ecosystems? (EP&Cs III)

Week Two and Three:

- What earth systems cause feedback cycles within California ecosystems? (NGSS DCIs: ESS2.A and ESS3.D; EP&Cs III)

- What distinctive properties of water enable life on our planet and at your restoration site? (NGSS DCI: ESS2.C)

- What factors influence climate within a given ecosystem? (NGSS DCI: ESS2.D)

- How have biogeochemical cycles, natural systems, and related ecosystem services in the atmosphere and hydrosphere been influenced by human-caused global warming? (NGSS DCIs: ESS3.C and D; EP&Cs II, III, and IV)

Week Three and Four:

- How can we define and delineate nature-based engineering solutions using the following parameters: cost, safety, reliability, aesthetics, social, cultural, and environmental, in a restoration plan? (NGSS DCIs: ETS1.A and B; EP&Cs V)

- How can global climate models be used to analyze cycles in natural systems? (NGSS DCIs: ESS2.A and ETS1.B; EP&Cs III)

Lanphere Dunes. Photo: Andrea Pickart

Invitation to Engage:
Restoring Our Land and Water

> **Challenging Question: How can we use science, policy, and nature-based engineering practices for ecological restoration in California?**

Aldo Leopold, an author, ecologist, and conservationist, alluded to the human-altered landscape of the United States as a "world of wounds." We can find some of these wounds in California's coastal watersheds—in dams thwarting steelhead bound for spawning grounds, in low water flows, in algal blooms, in invasive species crowding out native plants and animals. Restoration ecology, an applied scientific discipline, can help us move toward a healing of these wounds.

Installing native plants at Upper Newport Bay

The fruits of restoration ecology projects are becoming visible in watersheds all over California from the South Coast's Tijuana River Estuary, to the North Coast's Mad River, and inland to the Sierra, by government agencies, nonprofit organizations, citizen scientists, landowners, and students. Effective action can take many forms. In some cases, the goal is to restore habitat that has been degraded or destroyed. In other cases, new habitat is integrated into a built environment. Some brief examples of the breadth of possibilities include:

Carpinteria Creek, Santa Barbara County
Federal, state, and local government, with nonprofit partners including South Coast Habitat Restoration, came together to restore this creek. Eleven barriers impeding steelhead trout spawning, including low bridges and related concrete channels built in the early 1900s, were removed. New bridges were built to maintain access across the creek. The creek channel bed was restored with rocks and woody debris and native riparian plants were installed along the banks. Funding was provided by a range of government entities and private landowners.

Hamilton/Bel Marin Keys Wetlands, Marin County
This wetlands restoration project includes 2,600 acres along San Pablo Bay. One hundred years of farming on the former marsh had resulted in a land elevation below the lowest tides, so a necessary part of the restoration was depositing six million cubic yards of sediment (dredged from the Port of Oakland). Once the land was high enough to establish wetland plants, a

levee was breached to allow water to flow between the restoration area and the bay. Public walking trails were established around the site and native plant restoration continues, some of it with volunteer labor. This wetlands restoration is a joint project between the US Army Corps of Engineers and the California State Coastal Conservancy.

Lanphere Dunes, Humboldt County
Dunes are subject to harsh conditions and have low soil fertility, to which their native plant species have evolved. Invasive species may over-stabilize the dunes and change the soil properties. For decades, the US Fish and Wildlife Service, the Nature Conservancy, Friends of the Dunes, and other government and nonprofit organizations have been working to restore Lanphere Dunes. Invasive European beachgrass and yellow bush lupine are removed with shovels or heavy equipment when needed. Native California dune grass is planted in place of the European species. This work continues with extensive community volunteer support.

Eelgrass in Upper Newport Bay, Orange County
With a variety of local, state, and federal funding, Orange County Coastkeeper is engaging volunteers in eelgrass restoration. They are evaluating several different methods of installing the eelgrass, which are first harvested from nearby "donor" beds. While restoring habitat for wetland species, this project may also help fight climate change as research shows that eelgrass and other seagrass beds can store more than twice as much carbon per square kilometer as a typical forest.

Olympia Oysters in Elkhorn Slough, Monterey County
Elkhorn Slough National Estuarine Research Reserve is working to restore the Olympia oyster population in the slough. These native oysters are currently in danger of local extinction although they were once abundant there. Scientists are evaluating various methods of placing small reefs (made from clam shells) that provide a hard substrate on which the oysters can attach. Native oysters provide a variety of ecosystem services including shoreline erosion protection and water filtration.

Hubert Bancroft Elementary School, Sacramento County
Schoolyards are often overlooked seas of grass and pavement, but when the opportunity to create wildlife habitats and outdoor classrooms arise, campuses can be re-characterized as oases for students and wildlife. That's just what happened at Hubert Bancroft Elementary School when students designed a Schoolyard Habitat masterplan for their campus that included an "Alphabet" pollinator garden, walking trails, and a gazebo. The project was funded and implemented by donations from various community partners, the U.S. Fish and Wildlife Service, as well as a school-wide jog-a-thon.

The Issue:

Restoration of degraded habitats is complex business, especially in a world where natural systems are fast changing due to accelerated global warming and associated sea level rise. Successful ecological restoration can support native species populations, improve ecosystem services, and bring communities together.

Interns working in the UC Irvine greenhouse

Objective:

To investigate the science and practice of ecological restoration and design a restoration project for a chosen location.

Complicating factors:

Ethical, cultural, scientific, and process questions must be considered before any restoration work can begin. Some of the complicating factors may include:
- Disagreements about the best use of a piece of land.
- Conflicts between the needs of wildlife and the needs of people. For example, should there be a trail in a restored area, and if so where should it be placed?
- Issues of long-term maintenance. If a restoration project is completed, who will make sure it is not overrun by weeds in future years?
- Questions regarding habitat functions—will the restored habitat provide the beneficial functions anticipated?
- Questions of land ownership and legal requirements.
- Projected future changes in the site conditions due to climate disruption.

What will students do?

1. You will work in teams to design, evaluate, and refine a quantitative solution for reducing the impact of human activity on the physical environment and restoring biodiversity in a chosen ecosystem.

    a. After investigating an example of a restoration project, teams will select a site for their restoration plan, with teacher input, and develop guiding questions for their research.

    b. Teams will launch their investigation and create a restoration plan that includes consideration of ethical, political, cultural, financial, and ecological factors. Teams will communicate their ecological restoration plan to a public audience.

2. You will partner with a local nonprofit or governmental organization to organize or participate in a restoration activity. The field experience may focus on living or nonliving features of the ecosystem and shall be at least six hours in length, preferably requiring two to three visits.

How will teams be organized?

Science, Engineering, and Policy (SEP) teams of four students will be developed to focus upon a project of their choosing. Students will adopt (or rotate) science, engineering, and policy roles for the investigation. A fourth student will act as the Principal Investigator, or team leader.

How will students document their work?

1. With their teams, students will draft, revise, and finalize a detailed restoration project plan with graphics, quantitative analysis, and images of the restoration project site.
2. Students will maintain individual science notebooks documenting daily progress.
3. Students will practice, revise, and present their group's proposed restoration plan to a public audience.

Audience for Public Presentation:

Adult decision-makers ranging from government officials, landowners, district administrators, and teacher-leaders.

Elements of a Restoration Plan might include:

1. History and ownership of the site, including impacts of human activity
2. Current features of the site (include a sketch of existing site conditions)
   a. Vegetation (dominant vegetation types, any rare species)
   b. Hydrology (including streams or other water features)
   c. Soil type (if relevant)
   d. Wildlife usage
   e. Man-made features (such as culverts, bridges, etc.)
3. Goals and objectives of restoration plan (include a sketch of proposed plan for site, including a plant palette, if relevant)
4. Projected climate change impacts to the site and explanation of how plan addresses them
5. Restoration activities (to meet goals and objectives e.g. site preparation, planting plan, irrigation, fencing, signage).
6. Maintenance and monitoring plan
7. Public outreach and reporting

Student Checklist:
Restoring Our Land and Water

> **Challenging Question:** How can we use science, policy, and nature-based engineering practices for ecological restoration in California?

Add due dates to the following tasks and phases as instructed by your teacher.

Phase 1: Invitation to Engage, Explore Challenging Question, & Organize

Ask significant questions and define problems as you launch your project.

O Read *Invitation to Engage: Restoring our Land and Water*. Review rubrics.

O After you are assigned to a group, you will adopt a role as a principal investigator, scientist, engineer, or policy analyst and develop a brief job description for the role. These roles may be adopted for the length of the project, or rotated within your group. Accept or modify the Challenging Question with your group and teacher.

O Investigate an existing restoration project via online reports and news articles, documenting what you learn in your science notebook. Discuss within your group ethical, political, cultural, financial, and ecological factors influencing the decisions that were made in the process of completing the project.

O With your teacher's guidance, work as a team to identify a project site for which your team will create a restoration plan.

O Through your research, get familiar with what constitutes a restoration plan. There will be a range of options and solutions for any given site. Create an initial need-to-know list of relevant questions to launch your site investigation.

O Research and begin to make contact with a local organization or government agency to arrange for your local volunteer field experience. Read *Guide to Volunteer Restoration Field Work*.

Phase 2: Explore Questions, Existing Models, and Knowledge

During the second phase of the project you will work in your group to explore, analyze, and interpret qualitative and quantitative data related to your need-to-know questions.

Photo: Tolowa Dunes Stewards

O Individually, perform a self-assessment of Phase 1 and write a brief plan of improvement to turn in to your teacher.

O   Read *Asking the Right Questions*. Working with your group, use the Question Formulation Technique to refine your need-to-know list of relevant questions developed in Phase 1.

O   With your group, develop a draft statement of the specific problem(s) your restoration plan will address. (This may change as your group conducts its investigations.) Meet with your teacher to review and gain approval for your site and problem statement.

Photo: Youth Exploring Sea Level Rise Science

O   Use your need-to-know questions to launch your investigations, assigning specific questions to group members by role, skills, or individual preference. If your plan includes interviews, be sure to contact the subjects well in advance to set up appointments. Once you have completed the investigations, work as a group to synthesize and record the results. (Your teacher may ask you to turn these in or share them with your class.) Discuss how you will use these results to develop a restoration plan for your selected site. Do you have all the information you need? If not, assign and collect the missing information. Review existing ecological restoration principles or philosophies.

O   Participate in local volunteer restoration work as arranged.

Phase 3: Explain and Evaluate Claims, Argue from Evidence, and Reason

Take time now to compare and contrast claims within your group. Each claim is a response to either the challenging question or a related, need-to-know question. In this phase, you will complete planning for the presentation of your ecological restoration plan.

O   Read the *Claims, Evidence, and Reasoning Guide*. Based on the results of your investigations, revisit and refine your problem statement and develop several alternative approaches to a restoration solution for your site. Group members can devise individual solutions or you can work as a group to come up with several alternatives. Review and compare these approaches. Record all the claims you can make regarding each approach, and the evidence to support each claim. Evaluate the strengths and weaknesses in restoration principles or philosophies as you consider your own proposed restoration approaches. Evaluate the quality and credibility of your sources.

Monitoring at Lake Merritt. Photo: City of Oakland

O   Select your best restoration plan elements. Share them as directed by your teacher, and revise based on feedback.

O   Read *Communicating Science and Policy to Public Audiences*.

O   Complete your restoration plan and create visual presentation materials. Practice and review your presentation with the *Presentation Rubric*.

O   Individually, perform self-assessment and write a plan of improvement, as directed by your teacher. Submit project notebook to teacher for review.

Monitoring restoration at Upper Newport Bay

O   Confirm arrangements for any off-site presentations if applicable.

O   Participate in local volunteer restoration work as arranged.

Phase 4: Extend into Action: Communicate your Restoration Plan

Your primary academic role towards the end of the project is to communicate your science, engineering and policy solutions using visual tools, models, media presentations, or written products.

O   Perform technology checks on any equipment that will be needed for final presentations and follow up with invited guests to confirm attendance at least 24 hours in advance of the scheduled presentation. Present your proposed restoration plan to your audience.

O   Perform self-assessment and peer reviews, as directed by your teacher.

O   Submit individual project notebook to teacher for review.

O   Complete local volunteer restoration work as arranged.

Phase 5: Reflecting, Evaluating, and Celebrating

Ask yourself how you could improve while your successes and failures are still fresh in your mind.

O   Organize a group debrief with teacher. Have any new questions emerged?

O   Write thank you notes to any adult mentors and partners.

O   Perform a final self-evaluation, as directed by your teacher.

O   Celebrate with your hard working team!

A Guide to Volunteer Restoration Field Work

For those contemplating restoration projects, the complexity of the process can be overwhelming. The field experience will make restoration tangible and will help bring clarity to this complex effort. To review your assignment:

- Students will partner with local professionals and their organizations to perform a restoration activity.

- The field experience may focus on restoration of living or nonliving features of natural environments and shall be at least six hours in length, preferably requiring two to three visits. Some examples of field activities are planting native plants, removing invasive species, removing trash and/or other human-caused environmental harm, and conducting water quality monitoring.

Photo: Cachuma Resource Conservation District

- Teachers will facilitate the process, but students are responsible for arranging the field experience.

Note that this activity will most likely qualify for any community service requirements that your school may have; be sure to coordinate as needed.

Installing willows at Upper Newport Bay

What does restoration ecology look like in the field?

The Society for Ecological Restoration (SER) defines ecological restoration as: *the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed.* Robert Cabin, an author, restoration ecologist, and college professor advocates for "intelligent tinkering," an approach to restoration that weaves formal science together with hands-on practical experience in the field, celebrating both knowledge that originated in a university lab as well as traditional ecological knowledge. Traditional ecological knowledge is a term for "the knowledge, practices, and innovations" of indigenous people or local communities (SER, 2016).

For the purposes of this field experience, we adopt a broad definition of restoration ecology that encompasses a range of positive actions that will contribute to healing the planet. This is where intention turns to impact, academic knowledge grows into action, and students evolve into practicing restoration ecologists.

Photo: San Mateo County Resource Conservation District

Use your own community knowledge to identify three organizations with whom you might work, then narrow down your choice. If you need help, take a look at the Creeks to Coast Directory at www.coastal.ca.gov/creekstocoast, and at the list of organizations at the bottom of this reading. In addition to nonprofit organizations, you may find opportunities at national wildlife refuges, state and national parks, national forests, and water districts. Some organizations hold regular volunteer days that you can easily join. If possible, choose one restoration project rather than dividing your time between multiple projects.

There are a many organizations doing restoration work in California. Gain a sense of the diversity of offerings by studying some of the following organizations' websites and the reporting of them in the media. This list is organized by location, roughly from north to south.

Tolowa Dunes Stewards

Friends of the Dunes

Cosumnes River Preserve

Golden Gate National Parks Conservancy

Save the Bay

Return of the Natives

Sequoia Riverlands Trust

Santa Barbara Audubon Society

Friends of Ballona Wetlands

Friends of the Colorado Lagoon

Palos Verdes Peninsula Land Conservancy

Community-Based Restoration and Education Program at Upper Newport Bay

San Elijo Lagoon Conservancy

San Dieguito River Park

Lakeside's River Park Conservancy

Photo: Mattole Restoration Council

Student Guide to Personalized Learning Plans

A Personalized Learning Plan should include your personal learning goals for the project and the steps you will take to reach the goals. This plan will help you and your teacher track your progress toward mutually agreed upon learning outcomes.

Write **two personal learning goals** for use with the project. These goals can personalize the challenging question, refine the project products, modify the learning process, or connect your project to more than one subject area. Goals 1 and 2 should be:

1. An interest-based goal related to the project topic, your desired new knowledge, and/or how to apply the knowledge.

2. A Habits of Mind goal specifically related to applying knowledge in the real world.

List the steps you will take to reach each goal. How will you attain your goal? Try to phrase these steps as "I will" statements.

16 Habits of Mind Goals:

- Persisting
- Managing impulsivity
- Listening with understanding and empathy
- Thinking flexibly
- Thinking about thinking (metacognition)
- Striving for accuracy
- Questioning and posing problems
- Applying past knowledge to new situations
- Thinking and communicating with clarity and precision
- Gathering data through all senses
- Creating, imagining, innovating
- Responding with wonderment and awe
- Taking responsible risks
- Finding humor
- Thinking interdependently
- Remaining open to continuous learning

Arthur L. Costa and Bena Kallick, 2000

Specific:

Journalists ask themselves five questions when attempting to get complete stories: what, who, when, where and why. You can use this approach to write specific goal statements. For instance "What human actions (what) pose a risk to blue whales (who and why) in the Santa Barbara Channel (where) during the busy summer months (when)?"

Measurable (Observable):

What will your peers and teachers see and hear that demonstrates your success? For example, a choice to focus on developing your ability to persist to completion despite distractions would:

- Look like you continuing to work on your project tasks despite a busy classroom.
- Sound like you asking clarifying questions, considering alternative problem solving strategies, and asking for help when needed.

Consider quantifying your goals. For example, if asking clarifying questions is tough for you, set a goal of speaking twice per class period, even simple restatements or observations. If staying on task is an issue for you, set a goal of sitting where you will not be distracted by others or concentrating for increasing amounts of time.

Attainable:

Ask yourself if this is achievable goal? Removing an obsolete dam in just six weeks is an unrealistic goal. By contrast, bringing public attention to the damage caused by the dam to local watersheds and beaches by writing editorials, creating podcasts, or by taking local officials to the site is both doable and extremely valuable.

Relevant to your own life and education requirements:

Is the goal consistent with your greater needs and desires? Those students preparing for immediate college attendance after high school may want to set goals related to expected majors. A student planning to spend the summer watching their younger siblings might be interested in issues affecting children. Your teacher will lead the co-authoring of the education requirements section of the personal learning plan.

Timely:

Be sure to include realistic target dates for all elements of your plan.

NOTES FOR YOUR PERSONALIZED LEARNING PLAN:

Group Work Contract

Goals of the Group Contract

TEAM MEMBER NAME	TEXT NUMBER	EMAIL ADDRESS

Team Member's Role and Name	Team Member's Responsibilities. Be as specific as possible. Include performance indicators, tasks, and due dates.
Principal Investigator	
Scientist	
Engineer	
Policy Manager	

Group Contract Page 1

Option for Team Members: Share a goal from your Personalized Learning Plan

Group Agreements

Consequences for Breaking Agreements

1. Team members will issue one friendly reminder, as needed.
2. Team will issue a written formal joint warning. Teacher must know that warning was issued, but does not need to be involved.
3. Team member will be removed from the group and given an opportunity to re-join the group after make up work is performed. Team must schedule a problem-solving conference.
4. Team member will be removed permanently from the group. Team meets with teacher during office hours prior to permanent removal. If a team member is "fired," that person is responsible for completing an alternative project of the teacher's design.

Group Contract Page 2

California Coastal Voices, by the California Coastal Commission

Group Contract Signature Page

We have co-authored this contract, understand its contents, and agree to abide by every word. I am acknowledging my willingness to be held accountable to the group with my signature below.

Printed Name:

Signature:

Printed Name:

Signature:

Printed Name:

Signature:

Printed Name:

Signature:

Group Contract Page 3

Teacher Checklist for Student-Driven Projects

Prepare for Projects (3 to 6 weeks prior to entry event)

This is always the busiest time for a project-based teacher. With planning most projects go well, if not exactly where you thought they would. This is normal and expected in student-driven project-based learning environments.

O   Review project materials, standards, and teacher support pieces.

O   Organize a local guest speaker, videoconference, or a phenomenon for the project's Entry Event. Arrange space for public presentations of learning products if appropriate, and invite audience. Arrange speakers, adult mentors, and transportation for off-site activities.

O   Contact teachers from other departments and propose partnerships.

O   Perform a safety survey of any outdoor sites involved with the project.

O   Prepare for "just in time teaching" by reading the project's *Teacher Guide*.

O   Identify mutually reinforcing activities from existing curriculum guides.

Most importantly, prepare students for collaborative work, self-assessment, and sense-making conversations. See Create a Culture of Inquiry discussion in the Teacher Support reading titled *Organizing for Student Success*.

Launch Projects with an Engaging Entry Event (first week of project)

Your primary task when launching the project is to ensure a truly engaging entry event. Be sure that your speaker is prepped, knows how to connect to teenagers, and has visual aids or activities that prompt need-to-know questions. If quality speakers can't be found consider videos or video conferencing. Students receive the *Invitation to Engage* reading, *Rubrics*, and their *Student Checklist*; followed by the *Asking the Right Questions* reading.

O   Help students interact with guest speaker, video, or a natural phenomenon. Introduce the Challenging Question.

O   Encourage discussion of science, engineering, and policy viewpoints as students will be assuming these roles.

O   Check for prior knowledge and build place-based connections

O   Post the Challenging Question and create a calendar with student tasks. Use or revise the *Student Checklist* provided with the project or develop your own. (The *Student Checklist* and selected other documents are available in Word on the *Coastal Voices Website*, www.coastal.ca.gov/coastalvoices.)

O   Review the procedures for creating group contracts and personalized learning plans, if you are using them. Assign teams and create contracts. Make students aware of your grading procedure. One option is for groups to agree that they will be the ones responsible for dividing up points based on the level of work each student does on the group project.

O   Define the major learning products, which are typically the project notebook and a public presentation.

Manage the (Potentially) Messy Middle of Projects (3 to 4 weeks long)

This period of time is a cycle of questioning, knowledge building, explaining, revising understanding, and reflecting. Rarely is the middle of a project linear or predictable. Students may need all sorts of support ranging from direct instruction in process skills such as evaluating resources for bias, validity, and authority, to structured homework activities to clarify significant science concepts.

O Distribute the readings: *Claims, Evidence, and Reasoning*, followed by the field experience reading, *Tips for Effective Communication in Public Settings*, and any readings specific to the particular project. An additional reading is available titled, *Students Taking Action on Science & Policy and Communicating to Public Audiences*.

O In the second week, have students perform self assessment and write plans of improvement.

O Use a Daily Phenomenon (as described in the Teacher Support piece, Organizing for Student Success) to build shared knowledge as needed.

O Review project notebooks as often as time allows to ensure your ability to provide frequent feedback to students. Use exit tickets to track content knowledge and progress. Evaluate with rubrics.

O Have content resources ready that relate to students' "need-to-knows" and personalized learning plans. Deliver when students ask. Resist the impulse to front load or deliver lectures. Remember, this is "just in time" instruction.

O Perform weekly check-ins with groups using Habits of Mind descriptions. Perform additional team building activities as needed, however students should manage their own groups. In week three, meet with each group for debriefing on group work.

O As you get to week three increase the frequency of formative feedback. Be sure to review drafts of any written products and especially the project notebook.

O Use gallery walks as foundations for self- and peer-review.

O Provide frequent opportunities for students to practice.

O Confirm arrangements for public presentations and further adult mentoring opportunities. Send reminders to invited audiences.

Celebrate Student Work in Public Settings (last week of project)

Your primary role towards the end of the project is to facilitate reflection, support accurate student thinking by formally correcting when needed, and to celebrate the growth that you have noted during your regular formative assessment sessions.

O Perform system checks on any technology that will be used in presentations at least two days prior.

O Review rubrics, personalized learning plans, and performance expectations.

O Review the questions created at the beginning of the project.

O Have students perform self-assessment, lead reflection discussions, and write plans of improvement.

O Meet with each group for debriefing on group work. Have students divide points per original contract agreements, if applicable.

Asking the Right Questions

Projects, in school or out, are driven forward by questions and a sustained pursuit of inventive, evidence-based answers. Creative questioning is the motive force and the fire that will light your path forward as a self-directed learner. A quote attributed to Albert Einstein is, "It is not that I am so smart, it is just that I stay with the questions longer." An inclination to persistently question, explore alternative explanations, seek answers for oneself, and communicate solutions are key job skills.

If asking the "right question" is a key to achieving meaningful results, what is the right question? One starting point is that the "right question" is one that interests you, connects to your life, and relates to significant real world processes, events, phenomena, or relationships. This is a prime opportunity for exercising your voice and choice to shape your learning and our society.

The next section (adapted from Rothstein and Santana's *Question Formulation Technique*) provides a strategy your group may use to organize your questioning in order to launch your investigation.

1. **Design a question focus:** Take this project's Challenging Question as posed and rewrite it as an assertion or a statement. Then reverse engineer (pick apart) the challenging question as a starting point to develop your own focus question. You will notice that the question as it is stated has implicit assumptions, clear goals, and a target audience. Decide for yourself what part of the question intrigues you and suggests a focus for further questioning. However, you should question the question before adopting it as a guide for your learning.

2. **Produce questions:** Begin developing "need-to-know" questions to guide your research into the Challenging Question. Use these rules to brainstorm:

   Ask as many creative and probing questions as time allows. Feel free to riff off one another to keep things moving. For now, more is better; in a later step you will work to prioritize your questions.

   Do not stop to judge, edit, answer, or respond to any question during question generation.

   Have one group member write down each question exactly as posed. You may wish to rotate this task as it can inhibit the scribe's creativity.

   Change all assertions or statements into questions.

3. **Work to refine questions:** Seek to convert closed questions (yes/no) to open ended questions that will require more thought and investigation. Aim for higher-level thinking questions that require analysis, synthesis, and

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application of knowledge. Do you notice any patterns to the questions? Is there a way to investigate each question, and if not how can that question be restructured?

4. **Prioritize and classify questions:** You are being asked to investigate a complex issue. First, prioritize and narrow down your list of questions. Next, broadly categorizing the questions, for example, according to the group role (science, engineering, or policy) that will be leading each question's investigation.

5. **Plan how to investigate the questions:** What knowledge will be needed? Find out what is already known so your creative questioning will have the potential to explore new ground. The real skill lies in recognizing what data and information is valid, free of bias, and relevant to the question being asked.

   What will you be doing? Think carefully about what science, engineering, and policy practices will lead you to significant answers to the various questions. Observation, research, interviews, fieldwork, experiments, surveys, data mining, or a combination of approaches? Be sure to consider how you will obtain, evaluate, and communicate about these complex subjects.

   What will you be thinking about? Big ideas! Patterns, cause and effect relationships, policies that lead to stability or change. Models, of many system types: climate, transportation, communication, ecological, financial, or physical. How do the systems interact and function? What are the boundaries? Where do varied systems intersect? What are the component parts and what limitations exist?

6. **Commit to Next Steps:** This is an ideal time to finalize your learning contract and begin designing your investigation. See Student Checklist.

7. **Student Reflection:** Consider in your project notebook what steps you might take to improve your questioning skills. When does it feel most challenging to ask questions? How might you control circumstances that make you nervous? Consider setting a goal to ask a question every day.

Students of the art and science of questioning are doing far more than setting the learning agenda for themselves; they are training themselves in a new way of thinking that leads to innovation, career success, and mental habits that may be applied across subject areas, lifestyles, and geography. Author and poet Harvey Oxenhorn illustrates the ultimate positive outcome for questioners: "Being mindful...To notice everything, to make that level of awareness so habitual that it became unconscious…To get in the habit of asking questions was to get in the habit of answering them for yourself. What you gain in the process, when allowed to make your own mistakes, is self-reliance, ability, and independence."

Claims, Evidence, and Reasoning Guide

For our individual impacts to be positive, people of every age must practice speaking, arguing, and acting with clarity and precision based on carefully developed evidence. Today's complex social and environmental issues require nuance in expression, effective listening and speaking skills, and an ability to distinguish between closely related topics. Developing evidence for yourself, analyzing counter arguments, and making well-reasoned claims leads to confidence and assertiveness.

Key Terms and Concepts

Argumentation is the process of supporting claims, assertions, proposed solutions, conclusions, or models with solid reasoning based on valid evidence. This guide uses examples drawn from environmental science and policy; however, it is important to remember that arguing from evidence is an appropriate strategy for working in any career area.

The UC Berkeley Museum of Paleontology defines the word "evidence" as used by scientists and engineers as:

> *Test results and/or observations that may either help support or help refute a scientific idea. In general, raw data are considered evidence only once they have been interpreted in a way that reflects on the accuracy of a scientific idea.*

Notice that science is a conversation, an open process of testing ideas via practices that always converge on the use of evidence to revise knowledge. New evidence, once corroborated through peer review, will be used to revise existing theory. Engineers behave similarly and often use a process known as Evidence-Based Design, a method for everything from the design of buildings to medical studies. The emphasis is on observable, experiential, and testable phenomena.

Evidence is also important for professionals in legal and policy fields. Notice how the underlying principle of a claim being supported by evidence is expressed in the following definition from the California Legal Code:

> *"Evidence" means testimony, writings, material objects, or other things presented to the senses that are offered to prove the existence or nonexistence of a fact.*

For this project, we will define the terms "claim," "evidence," and "reasoning" as follows:

Claim:

As used for this project, a claim is a statement that answers the Challenging Question or an essential question developed by student teams. It will always be supported by evidence and scientific reasoning, and be consistent with logic. It is never an opinion, belief, or preference. Your ability to construct viable arguments, claims, and explanations rests upon obtaining, evaluating, and communicating from a foundation of evidence.

Evidence:

For this project we seek evidence in the form of organized data from relevant, reliable sources; direct observation of a phenomenon; experiments; or carefully constructed student surveys. Data must first be organized and interpreted before it is considered evidence supporting a claim.

Reasoning:

This is the link between your claim and the evidence supporting the claim. It is the rationale for why your claim is warranted based on your evidence. We can all recall a situation where a question was met with a dismissive "because it's in the text book." In this project we are looking for much more—typically three sources of evidence to support any claim.

Robust reasoning will have four distinct elements: First, you must clearly articulate your claim (your proposed answer to the Challenging Question). Second, describe any patterns or trends in the data cited. A complete description of how the data was obtained, what circumstances prevailed during collection, and any possible weaknesses in the evaluation process are markers of quality. Third, provide a statement of correlation that supports your claim. For example, if the claim is that "high park admission costs are a barrier to access for youth," a related correlative statement could be, "we expected an inverse correlation between admission price and park visits by young people. We did see this result in park data collected after price increases and in our surveys of 300 students." Finally, high quality reasoning considers alternative explanations for any claim or explanation: "We considered other explanations related to public transit access and availability of parking. These are factors, however our results strongly suggest that there is a relationship between cost and youth visits to parks."

Creating a Scientific or Policy Argument

Adapted from NSTA and the California NGSS Roll-Out

Goals: **1.** Create an argument consisting of a claim, supporting evidence, and reasoning. **2.** Revise the argument based on feedback from peers.

Our first draft of CLAIM-EVIDENCE-REASONING	Comments from peers on improving our work	Our improved draft of CLAIM-EVIDENCE-REASONING
CLAIM: Here is our claim (...we believe that X is caused by...OR we believe that Y has a role in how Z happens...)	Is the claim clear? Does it describe a cause and effect?	**Revised CLAIM**
EVIDENCE: Our evidence comes from (name the type of data and the activity it came from). We saw in the data (name the particular trend or outcome).	Is the data relevant to the claim being made? If two kinds of data or observations are being compared, do they make sense to use together? Is the data credible?	**Revised EVIDENCE**
REASONING: We think this evidence supports our claim because if these trends in data are happening, then it means that (state a brief causal chain of events—this chain has to be consistent with known science ideas/facts).	Do you need to make big inferences about what happened or why? Are there big gaps in the causal story here? If you saw this kind of data, does it mean that their claim can be the ONLY one that is true? Should they moderate their claim?	**Improved REASONING**

Tips for Effective Communication in Public Settings

Public speaking is a fundamental challenge, potentially stressful or frightening for many people, both adults and students. To find your voice, speak intelligently from evidence, and be self-confident when challenged about the questions of the day, is to find your own power and your own chance to change the world. Speaking in 2014, 17 year old Nobel Prize winner Malala Yousafzai said: "We should not wait for someone else to come and raise our voice. We should do it by ourselves."

Since sharing your work in public through presentations, field experiences, or media is central to this project, to civic participation, and to changing the world, this document describes some techniques of public speaking that with practice will grant anyone the ability to move from academics to action.

1. **Prepare well.** Georgia State Professor Michael Mescon puts it this way: "The best way to conquer stage fright is to know what you are talking about." This is a close cousin to the US Navy's principle of 7Ps. Here is the cleaned up, non-sailor version: Prior Planning, Preparation, and Practice Prevents Poor Performance. Reinforcing this from ancient Greece is Epictetus, who spoke to the importance of listening and learning before speaking with this anatomically apt reminder: "We have two ears and one mouth so we may listen twice as much as we speak." Listening is preparing. Once you are in command of the facts, the evidence, and the reasoning, it becomes natural to assert your claim.

2. **Practice, practice, practice, and practice again.** Audiences are forgiving of mistakes, nervousness, and stage fright; however, it is disrespectful to waste their time though lack of preparation.

3. **Speak only about what you know to be true and don't fake it.** In his letters home from the Middle East, Malcolm X wrote, "I'm for truth, no matter who tells it. I'm for justice, no matter who it's for or against." Speak only about what you know and be happy to offer a professional "I don't know but I will find out and get back to you." Once again, audiences expect you to be knowledgeable about your message, prepared to deliver in an effective manner, and honest, but no one expects you to know everything.

4. **Speak slowly and clearly.** Many people speed up their speech when they are nervous, but that makes you harder to understand and the audience might miss parts of what you are saying. Slow down your speech and take your time.

5. **Make eye contact with the audience.** This is a tip that will help engage your audience in what you are saying—making it feel more like a conversation than a speech. Don't just scan the audience—look at individual audience members one at a time. Try to give them an entire sentence or thought before moving on to another person.

6. **Say thank you.** Your audience's presence and applause are a gift. At the end of your presentation, always acknowledge your audience by thanking them.

Creativity & Innovation Opportunity at Phases of a Project	Below Standard	Approaching Standard	At Standard	Above Standard
Launching the Project: Define the Creative Challenge	• may just "follow directions" without understanding the purpose for innovation or considering the needs and interests of the target audience	• understands the basic purpose for innovation but does not thoroughly consider the needs and interests of the target audience	• understands the purpose driving the process of innovation (Who needs this? Why?) • develops insight about the particular needs and interests of the target audience	
Building Knowledge, Understanding, and Skills: Identify Sources of Information	• uses only typical sources of information (website, book, article) • does not offer new ideas during discussions	• finds one or two sources of information that are not typical • offers new ideas during discussions, but stays within narrow perspectives	• in addition to typical sources, finds unusual ways or places to get information (adult expert, community member, business or organization, literature) • promotes divergent and creative perspectives during discussions (CC 11-12.SL.1c)	
Developing and Revising Ideas and Products: Generate and Select Ideas	• stays within existing frameworks; does not use idea-generating techniques to develop new ideas for product(s) • selects one idea without evaluating the quality of ideas • does not ask new questions or elaborate on the selected idea • reproduces existing ideas; does not imagine new ones • does not consider or use feedback and critique to revise product	• develops some original ideas for product(s), but could develop more with better use of idea-generating techniques • evaluates ideas, but not thoroughly before selecting one • asks a few new questions but may make only minor changes to the selected idea • shows some imagination when shaping ideas into a product, but may stay within conventional boundaries • considers and may use some feedback and critique to revise a product, but does not seek it out	• uses idea-generating techniques to develop several original ideas for product(s) • carefully evaluates the quality of ideas and selects the best one to shape into a product • asks new questions, takes different perspectives to elaborate and improve on the selected idea • uses ingenuity and imagination, going outside conventional boundaries, when shaping ideas into a product • seeks out and uses feedback and critique to revise product to better meet the needs of the intended audience (CC 6-12.W.5)	

CREATIVITY & INNOVATION RUBRIC, PROCESS, continued

Creativity & Innovation Opportunity at Phases of a Project	Below Standard	Approaching Standard	At Standard	Above Standard
Presenting Products and Answers to Driving Question: Present Work to Users/Target Audience	• presents ideas and products in typical ways (text-heavy slides, recitation of notes, no interactive features)	• adds some interesting touches to presentation media • attempts to include elements in presentation that make it more lively and engaging	• creates visually exciting presentation media • includes elements in presentation that are especially fun, lively, engaging, or powerful to the particular audience	

PRODUCT:

	Below Standard	Approaching Standard	At Standard	Above Standard
Originality	• relies on existing models, ideas, or directions; it is not new or unique • follows rules and conventions; uses materials and ideas in typical ways	• has some new ideas or improvements, but some ideas are predictable or conventional • may show a tentative attempt to step outside rules and conventions, or find new uses for common materials or ideas	• is new, unique, surprising; shows a personal touch • may successfully break rules and conventions, or use common materials or ideas in new, clever and surprising ways	
Value	• is not useful or valuable to the intended audience/user • would not work in the real world; impractical or unfeasible	• is useful and valuable to some extent; it may not solve certain aspects of the defined problem or exactly meet the identified need • unclear if product would be practical or feasible	• is seen as useful and valuable; it solves the defined problem or meets the identified need • is practical, feasible	
Style	• is safe, ordinary, made in a conventional style • has several elements that do not fit together; it is a mish-mash	• has some interesting touches, but lacks a distinct style • has some elements that may be excessive or do not fit together well	• is well-crafted, striking, designed with a distinct style but still appropriate for the purpose • combines different elements into a coherent whole	

Note: The term "product" is used in this rubric as an umbrella term for the result of the process of innovation during a project. A product may be a constructed object, proposal, presentation, solution to a problem, service, system, work of art or piece of writing, an invention, event, an improvement to an existing product, etc.

Courtesy of the Buck Institute for Education

	Below Standard	Approaching Standard	At Standard	Above Standard
Explanation of Ideas & Information	• does not present information, arguments, ideas, or findings clearly, concisely, and logically; argument lacks supporting evidence; audience cannot follow the line of reasoning • selects information, develops ideas and uses a style inappropriate to the purpose, task, and audience (may be too much or too little information, or the wrong approach) • does not address alternative or opposing perspectives	• presents information, findings, arguments and supporting evidence in a way that is not always clear, concise, and logical; line of reasoning is sometimes hard to follow • attempts to select information, develop ideas and use a style appropriate to the purpose, task, and audience but does not fully succeed • attempts to address alternative or opposing perspectives, but not clearly or completely	• presents information, findings, arguments and supporting evidence clearly, concisely, and logically; audience can easily follow the line of reasoning (CC 9-12.SL.4) • selects information, develops ideas and uses a style appropriate to the purpose, task, and audience (CC 9-12.SL.4) • clearly and completely addresses alternative or opposing perspectives (CC 11-12.SL.4)	
Organization	• does not meet requirements for what should be included in the presentation • does not have an introduction and/or conclusion • uses time poorly; the whole presentation, or a part of it, is too short or too long	• meets most requirements for what should be included in the presentation • has an introduction and conclusion, but they are not clear or interesting • generally times presentation well, but may spend too much or too little time on a topic, a/v aid, or idea	• meets all requirements for what should be included in the presentation • has a clear and interesting introduction and conclusion • organizes time well; no part of the presentation is too short or too long	
Eyes & Body	• does not look at audience; reads notes or slides • does not use gestures or movements • lacks poise and confidence (fidgets, slouches, appears nervous) • wears clothing inappropriate for the occasion	• makes infrequent eye contact; reads notes or slides most of the time • uses a few gestures or movements but they do not look natural • shows some poise and confidence, (only a little fidgeting or nervous movement) • makes some attempt to wear clothing appropriate for the occasion	• keeps eye contact with audience most of the time; only glances at notes or slides • uses natural gestures and movements • looks poised and confident • wears clothing appropriate for the occasion	

PRESENTATION RUBRIC, continued

	Below Standard	Approaching Standard	At Standard	Above Standard
Voice	• mumbles or speaks too quickly or slowly • speaks too softly to be understood • frequently uses "filler" words ("uh, um, so, and, like, etc.") • does not adapt speech for the context and task	• speaks clearly most of the time • speaks loudly enough for the audience to hear most of the time, but may speak in a monotone • occasionally uses filler words • attempts to adapt speech for the context and task but is unsuccessful or inconsistent	• speaks clearly; not too quickly or slowly • speaks loudly enough for everyone to hear; changes tone and pace to maintain interest • rarely uses filler words • adapts speech for the context and task, demonstrating command of formal English when appropriate (CC 9-12.SL.6)	
Presentation Aids	• does not use audio/visual aids or media • attempts to use one or a few audio/visual aids or media, but they do not add to or may distract from the presentation	• uses audio/visual aids or media, but they may sometimes distract from or not add to the presentation • sometimes has trouble bringing audio/visual aids or media smoothly into the presentation	• uses well-produced audio/visual aids or media to enhance understanding of findings, reasoning, and evidence, and to add interest (CC 9-12.SL.5) • smoothly brings audio/visual aids or media into the presentation	
Response to Audience Questions	• does not address audience questions (goes off topic or misunderstands without seeking clarification)	• answers audience questions, but not always clearly or completely	• answers audience questions clearly and completely • seeks clarification, admits "I don't know" or explains how the answer might be found when unable to answer a question	
Participation in Team Presentations	• Not all team members participate; only one or two speak	• All team members participate, but not equally	• All team members participate for about the same length of time • All team members are able to answer questions about the topic as a whole, not just their part of it	

COLLABORATION RUBRIC

Courtesy of the Buck Institute for Education

Individual Performance	Below Standard	Approaching Standard	At Standard	Above Standard
Takes Responsibility for Oneself	• is not prepared, informed, and ready to work with the team • does not use technology tools as agreed upon by the team to communicate and manage project tasks • does not do project tasks • does not complete tasks on time • does not use feedback from others to improve work	• is usually prepared, informed, and ready to work with the team • uses technology tools as agreed upon by the team to communicate and manage project tasks, but not consistently • does some project tasks, but needs to be reminded • completes most tasks on time • sometimes uses feedback from others to improve work	• is prepared and ready to work; is well informed on the project topic and cites evidence to probe and reflect on ideas with the team (CC 6-12.SL.1a) • consistently uses technology tools as agreed upon by the team to communicate and manage project tasks • does tasks without having to be reminded • completes tasks on time • uses feedback from others to improve work	
Helps the Team	• does not help the team solve problems; may cause problems • does not ask probing questions, express ideas, or elaborate in response to questions in discussions • does not give useful feedback to others • does not offer to help others if they need it	• cooperates with the team but may not actively help it solve problems • sometimes expresses ideas clearly, asks probing questions, and elaborates in response to questions in discussions • gives feedback to others, but it may not always be useful • sometimes offers to help others if they need it	• helps the team solve problems and manage conflicts • makes discussions effective by clearly expressing ideas, asking probing questions, making sure everyone is heard, responding thoughtfully to new information and perspectives (CC 6-12.SL.1c) • gives useful feedback (specific, feasible, supportive) to others so they can improve their work • offers to help others do their work if needed	
Respects Others	• is impolite or unkind to teammates (may interrupt, ignore ideas, hurt feelings) • does not acknowledge or respect other perspectives	• is usually polite and kind to teammates • usually acknowledges and respects other perspectives and disagrees diplomatically	• is polite and kind to teammates • acknowledges and respects other perspectives; disagrees diplomatically	

COLLABORATION RUBRIC, continued

Team Performance	Below Standard	Approaching Standard	At Standard	Above Standard
Makes and Follows Agreements	• does not discuss how the team will work together • does not follow rules for collegial discussions, decision-making and conflict resolution • does not discuss how well agreements are being followed • allows breakdowns in teamwork to happen; needs teacher to intervene	• discusses how the team will work together, but not in detail; may just "go through the motions" when creating an agreement • usually follows rules for collegial discussions, decision-making, and conflict resolution • discusses how well agreements are being followed, but not in depth; may ignore subtle issues • notices when norms are not being followed but asks the teacher for help to resolve issues	• makes detailed agreements about how the team will work together, including the use of technology tools • follows rules for collegial discussions (CC 6-12.SL.1b), decision-making, and conflict resolution • honestly and accurately discusses how well agreements are being followed • takes appropriate action when norms are not being followed; attempts to resolve issues without asking the teacher for help	
Organizes Work	• does project work without creating a task list • does not set a schedule and track progress toward goals and deadlines • does not assign roles or share leadership; one person may do too much, or all members may do random tasks • wastes time and does not run meetings well; materials, drafts, notes are not organized (may be misplaced or inaccessible)	• creates a task list that divides project work among the team, but it may not be in detail or followed closely • sets a schedule for doing tasks but does not follow it closely • assigns roles but does not follow them, or selects only one "leader" who makes most decisions • usually uses time and runs meetings well, but may occasionally waste time; keeps materials, drafts, notes, but not always organized	• creates a detailed task list that divides project work reasonably among the team (CC 6-12.SL.1b) • sets a schedule and tracks progress toward goals and deadlines (CC 6-12.SL.1b) • assigns roles if and as needed, based on team members' strengths (CC 6-12.SL.1b) • uses time and runs meetings efficiently; keeps materials, drafts, notes organized	
Works as a Whole Team	• does not recognize or use special talents of team members • does project tasks separately and does not put them together; it is a collection of individual work	• makes some attempt to use special talents of team members • does most project tasks separately and puts them together at the end	• recognizes and uses special talents of each team member • develops ideas and creates products with involvement of all team members; tasks done separately are brought to the team for critique and revision	

Courtesy of the Buck Institute for Education

Critical Thinking Opportunity at Phases of a Project	Below Standard	Approaching Standard	At Standard	Above Standard
Launching the Project: Analyze Challenging Question and Begin Inquiry	• sees only superficial aspects of, or one point of view on, the Challenging Question	• identifies some central aspects of the Challenging Question, but may not see complexities or consider various points of view • asks some follow-up questions about the topic or the wants and needs of the audience or users of a product, but does not dig deep	• shows understanding of central aspects of the Challenging Question by identifying in detail what needs to be known to answer it and considering various possible points of view on it • asks follow-up questions that focus or broaden inquiry, as appropriate (CC 6-12.W.7) • asks follow-up questions to gain understanding of the wants and needs of audience or product users	
Building Knowledge, Understanding, and Skills: Gather and Evaluate Information	• is unable to integrate information to address the Challenging Question; gathers too little, too much, or irrelevant information, or from too few sources • accepts information at face value (does not evaluate its quality)	• attempts to integrate information to address the Challenging Question, but it may be too little, too much, or gathered from too few sources; some of it may not be relevant • understands that the quality of information should be considered, but does not do so thoroughly	• integrates relevant and sufficient information to address the Challenging Question, gathered from multiple and varied sources (CC 6,11-12.RI.7) • thoroughly assesses the quality of information (considers usefulness, accuracy and credibility; distinguishes fact vs. opinion; recognizes bias) (CC 6-12.W.8)	
Developing and Revising Ideas and Products: Use Evidence and Criteria	• accepts arguments for possible answers to the Challenging Question without questioning whether reasoning is valid • uses evidence without considering how strong it is • relies on "gut feeling" to evaluate and revise ideas, product prototypes or problem solutions (does not use criteria)	• recognizes the need for valid reasoning and strong evidence, but does not evaluate it carefully when developing answers to the Challenging Question • evaluates and revises ideas, product prototypes or problem solutions based on incomplete or invalid criteria	• evaluates arguments for possible answers to the Challenging Question by assessing whether reasoning is valid and evidence is relevant and sufficient (CC 6-12.SL.3, RI.8) • justifies choice of criteria used to evaluate ideas, product prototypes or problem solutions • revises inadequate drafts, designs or solutions and explains why they will better meet evaluation criteria (CC 6-12.W.5)	

CRITICAL THINKING RUBRIC, continued

Critical Thinking Opportunity at Phases of a Project	Below Standard	Approaching Standard	At Standard	Above Standard
Presenting Products and Answers to Driving Question: Justify Choices, Consider Alternatives & Implications	• chooses one presentation medium without considering advantages and disadvantages of using other mediums to present a particular topic or idea • cannot give valid reasons or supporting evidence to defend choices made when answering the Challenging Question or creating products • does not consider alternative answers to the Challenging Question, designs for products, or points of view • is not able to explain important new understanding gained in the project	• considers the advantages and disadvantages of using different mediums to present a particular topic or idea, but not thoroughly • explains choices made when answering the Challenging Question or creating products, but some reasons are not valid or lack supporting evidence • understands that there may be alternative answers to the Challenging Question or designs for products, but does not consider them carefully • can explain some things learned in the project, but is not entirely clear about new understanding	• evaluates the advantages and disadvantages of using different mediums to present a particular topic or idea (CC 8.RI.7) • justifies choices made when answering the Challenging Question or creating products, by giving valid reasons with supporting evidence (CC 6-12.SL.4) • recognizes the limitations of an answer to the Challenging Question or a product design (how it might not be complete, certain, or perfect) and considers alternative perspectives (CC 11-12.SL.4) • can clearly explain new understanding gained in the project and how it might transfer to other situations or contexts	

Indicators of Achievement Adapted from Costa and Kallick, NCTE, and NGSS

Habit of Mind	Unsatisfactory	Growing to Competency	Competent (State Standard)	Distinguished
Striving for Accuracy	Sloppy or incomplete work with no evidence of revision or editing process. Feedback from peer reviewers and adult collaborators is not incorporated into work.	Student occasionally reviews checklists, rubrics, and peer feedback to enhance written communications. Care is taken to convey significant science concepts with examples and data.	Student understands and can apply two to three relevant science concepts in a written sequence of claims, evidence, and reasoning. Student works with peers as instructional resources.	Without sacrificing scientific accuracy, student constructs a coherent storyline referencing California places, issues, and connections to his or her own life. Student demonstrates a command of writing mechanics, organization, and ability to revise and edit.
Creative Questioning	Student does not initiate questioning in any written or verbal form. When questions are asked, they focus on meeting minimum requirements as articulated by adults.	Student intiates science-based questioing with support from peers or teachers. The value of questioing is understood, but the habit is still being cultivated.	Student independently produces original questions, considers questions from multiple perspectives, and produces original answers. Student brainstorms with others during the questioning process and listens carefully to arguments made by peers.	Student uses science and engineering practices to develop personalized place-based driving questions with connections to science concepts and to the ideas of classmates. Student considers alternative perspectives and nurtures an inclination to question daily.
Applying Past Knowledge to New Situations	Science notebooks, feedback from peers, and previous experience does not inform actions or writing.	When reminded and supported, prior knowledge is accessed and used to improve speaking and written communications.	Student consistently uses prior knowledge to investigate new phenomena. Reference to previous experience or careful use of analogies may be seen.	Student consistently uses prior knowledge to investigate new phenomena. Reference to previous experience or careful use of analogies may be seen.
Thinking and Communicating with Clarity and Precision	Use of vague and imprecise language leads to confusion about meaning. Science vocabulary is missing or used incorrectly.	Science concepts and ideas are communicated using analogies from everyday life, but subtle distinctions are lost due to a lack of vocabulary or incomplete grasp of scientific concepts.	Student avoids generalizations and distortions of fact while clearly defining science terms, concepts, and ideas. Student can distinguish between closely related science topics (e.g. weather and climate, or heat and temperature).	Students use exact language to convey science concepts and emerging ideas. Claims are supported with evidence and reasoning that is grounded in place, personal experience, and relevant science concepts. Writing is concise, descriptive, and coherent.

SCIENCE NOTEBOOK AND EXIT TICKET RUBRIC

NGSS Element	Unsatisfactory	Growing to Competency	Competent (State Standard)	Distinguished
Crosscutting Concepts	Student does not show connections across content area boundaries. Most learning activity is limited to memorizing facts without context.	Student identifies patterns and classifies relationships as causal or correlational. Student understands that events that occur closely in time may or may not be related.	Student places significant knowledge in context using systems, models, and causal analysis. Student evaluates questions and models for testability, arguments for validity, and solutions for practicality.	Explanatory power of crosscutting concepts is fully utilized to think and write as scientists do while addressing real world environmental problems. Alternative explanations are routinely considered, as is instrument error.
Science and Engineering Practices	Student identifies testable questions and performs simple qualitative investigations, but fails to recognize the many ways that scientists perform their work.	Student specifies relationships, between variables and clarifies arguments, but rarely evaluates or proposes solutions.	Student uses evidence and computational thinking to analyze geoscience data, construct arguments, develop conceptual models, plan investigations, and propose science-based actions.	Science and engineering practices are habitually referenced in writing. System level thinking is demonstrated in reference to boundaries, interactions, and constraints posed by methods, society, or environmental concerns.
Disciplinary Core Ideas	Student does not demonstrate understanding of science content; science vocabulary is wholly absent.	Student can identify components, yet understandings about relationships between components are elusive. Placing knowledge in context, using thinking tools like the crosscutting concepts is rare, but increasing.	Student presents Earth systems that are dynamic, interactive, and composed of both living and non-living features, with feedback effects that may be altered by human activity. Science vocabulary is weilded with precision and clarity.	Writing is precise and clear with no composition or style errors leading to elegant place-based expression of science concepts. Student makes a personal connection to the information and acts upon valid science information.
Conceptual Models	Work is inaccurate, lacking most needed components; messy craftsmanship detracts from overall presentation and obscures meaning.	Poor craftsmanship obscures meaning. Model is missing an element needed to completely understand science concepts or make predictions.	Model is neat; all depictions are accurate, legible, and scientifically defensible. Models have components, relationships, and connections labeled. Predictions about future conditions may be made.	Models can be used to evalute the merits and disadvantages of various actions, generate predictions, and quantify relationships between components or variables.

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