PEI PACIFIC EDUCATION INSTITUTE

FieldDesign
Engineering Design for Field-Based Applications K-5

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FieldDesign: Engineering Design for Field-Based Application K-5

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Introduction

Introduction to FieldDesign

The environment provides everything humans need: clean air, clean water, healthy food, materials for shelter and much more. Humans are a part of the natural system, humans create systems: community infrastructure, political systems, economic systems, cultures and religions, technological systems, transportation systems, and all human systems impact the natural system. As a part of nature, we must accept responsibility for the impact our systems make. As the underpinning for our ability to live our lives, the environment provides an intrinsically engaging and authentic context for learning.

The Pacific Education Institute (PEI) provides educators with professional learning and instructional materials that demonstrate how to incorporate ecosystem concepts into the teaching of traditional academic subjects like science, math, civics, economics, art, and English language arts. Our method for program delivery is called the FieldSTEM® Model. Environmentally literate students can examine real-world issues, think critically about the relationship between humans and natural systems, and make informed decisions, while at the same time building problem solving and collaboration skills that will prepare them for civic, academic and career success.

Social, economic and environmental issues can illicit deep feelings and long held opinions which come from everyone's experience in life. As educators, creating a safe classroom culture is critical. In these classrooms ideas and thoughts can be expressed so others can learn new perspective or carefully critique the idea. The Common Core State Standards (CCSS) for English Language Arts (ELA) sets out guidelines for listening and speaking that align well with the FieldSTEM model. Educators must take a balanced approach to instruction, respectfully incorporate differing perspectives and points of view, and modeling how to evaluate information with intellectual honesty. Every individual has a bias, including the teacher, for this reason involving the learners in critical evaluation of data, results, models, conclusions, and opinions benefits all learners in the room.

The Pacific Education Institute envisions a scientifically literate citizenry making balanced decisions for sustainable communities. In order to accomplish this, students of all ages must be engaged in meaningful decisions in their communities. FieldSTEM, PEI's model for integrated, career connected, locally-relevant, field-based learning offers a path for teachers, schools and districts to begin to implement programming to prepare all students for post-secondary learning, careers and citizenship. FieldDesign offers a framework for educators to use to meet the Next Generation Science Standard (NGSS) call for increased engineering design by employing language and math skills and an understanding of natural and social systems to implement three-dimensional science outdoors.

The NGSS calls for conceptual shifts regarding how best to teach science. Driving this shift is the idea that performance expectations are the new standard. Performance expectations interweave the three dimensions of science: disciplinary core ideas, cross cutting concepts and the practices of scientific inquiry and engineering design. Teachers who teach to performance expectations engage students in meaningful activities and projects that lead to the students' ability to understand the core ideas at deeper levels because they are applying the content while practicing the process of science and considering how the new knowledge, they are building fits with their previous knowledge of crosscutting concepts. The shifts outlined in NGSS will teach science, applied in real-world settings, to reflect how science is practiced and experienced in the world.

FieldDesign, engineering design for field-based applications, is a meaningful platform to engage students in engineering with a real problem to solve so they are applying their research and analytical skills to understand situations in a deeper way. FieldDesign works in formal and informal settings and allows students to take ownership for their learning, research existing knowledge, design, optimize and implement projects to solve local problems. Students engage in authentic engineering to become educated, empowered citizens of the 21st Century.

For younger students the projects can be guided by a teacher. As students learn the skills needed to conduct science, educators should help them transition to projects they select. A teacher can set boundaries on the type of projects in order to manage the classroom effectively. When students are given choice, they become more active participants in education. If learning is to be valued beyond school, instruction must engage the learner in the processes of building the knowledge and skills. PEI's FieldSTEM model is integrated, career-connected, locally relevant, field-based learning designed to advance science literacy and inspire balanced decision making for a sustainable future. It is a process that encourages student-driven projects in their communities.

FieldDesign, a framework for engineering design outdoors, is a new addition to the FieldSTEM frameworks. It introduces a step by step guide to take the engineering practices and ensure that students incorporate thinking that leads to sustainable communities rather than teaching the practice of engineering disconnected from the systems, social and natural, that it affects. The steps will look like other models, but key additions require students to reflect on the impact to the ecosystems, social systems and stakeholder views.

FieldDesign & Science Notebooks

Why FieldDesign?

Engineering is fundamental to life, a transferrable and globally-applicable practice, superb at developing critical-thinking, and a remarkable platform for problem-solving. The NGSS directs that through education, students should understand the "influence of science, engineering, and technology on society and the natural world." However, while there is an array of engineering design curricula, none focuses on the role engineering design plays in field-based work with the requirement that students consider the ecological impact of the work they are doing. PEI believes that students need to know about the outdoor, field-based engineering, that is taking place every day, especially as it relates to natural resource and land management, environmental conservation, energy and water systems and agriculture. By learning about engineering design in these sectors, students can connect with their communities, industries and environment, and more fully explore NGSS' recommended considerations, such as: "All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, on the health of people and the natural environment." To really understand this concept, education must move beyond the textbook and the four walls of a classroom, into the field. And FieldDesign is a framework to help educators do this. Through FieldDesign, educators can complete projects such as: designing, building, and testing the effectiveness of Remotely Operated Vehicles (ROVs) to collect water and plant/animal samples, as part of lessons on invasive species or water quality, engineering a solution to a school yard erosion problem to ensure clean water for salmon in their local creek, working with a potato farmer so students can learn about and design solutions to agriculture threats like aphids. Regardless of the issue to be addressed, using FieldDesign, students can engineer and test unique tools that address problems and work to minimize the impact on the environment—powerful learning for students.

Why Science (FieldSTEM) Notebooks?

PEI promotes FieldSTEM: a model of instruction where traditional content areas are integrated to help students apply their learning in their communities. FieldSTEM notebooks are an instructional tool where students' ELA and math skills are utilized in service of developing student understanding about complex social and ecological questions, problems, issues and opportunities. FieldSTEM notebooks have many benefits. They provide a space for teachers and student to track students' thinking and practices - preparing them to be a part of the 21st century workforce, they provide opportunities to increase collaborative communication skills, and provide a vehicle for differentiated instruction.

To help develop globally competitive students, FieldSTEM notebooks provide a place for students to record observations and reflect on the evidence from their field investigations. Notebooks encourage active learning and provide opportunities for students to pursue their own interests and tackle authentic problems (Hargrove & Nesbit, 2003; Gilbert & Kotelman, 2005). With lessons that bridge relevant content this evidence can be used to engage students in collaborative inquiry as a way of learning content, connecting students' thinking and experiences with concepts, and providing opportunities to challenge students, to push them further. Educators must resist the temptation to provide pre-made scaffolds, worksheets, data chart, etc. for students and instead encourage students to embrace their need to learn and grow in their skills. Students will learn to develop effective tables for data collection only if they are allowed to struggle with the number of rows and columns and how to label them. Ultimately, opportunities like these provide students with the skills to think critically and make informed decisions.

A FieldSTEM notebook becomes real evidence of student learning and thinking, and a tool to shape future productive citizens. FieldSTEM notebooks can promote communication between students, teachers and parents or guardians by providing evidence of a student's conceptual understanding and personal reflections providing evidence for student-driven parent conferences where both student and parents or guardians are engaged with the material. It becomes a way of capturing common and individual experiences on paper where they won't get lost, where they can be referred to as needed to drive discourse. By providing student-friendly sense making tools, rubrics, feedback, scaffolding and modeling along with release of responsibility – a process where a teacher encourages and supports learners to design and monitor their own learning around classroom goals - this same evidence can be used by students to self-assess their growth in understanding or their capacity for doing. FieldSTEM notebooks expose students' thinking, providing important insights about student understanding and serving as formative assessment tools (Hargrove & Nesbit, 2003; Gilbert & Kotelman, 2005). This concrete record of reflection, assessment, and connections can be viewed and discussed by teachers who can gain an understanding of a students' thought process, sense-making and patterns across a classroom to modify instruction.

Providing opportunities for all students requires instructional strategies that ensure equity of access. Using modeled scaffolds (graphic organizers, writing frames, etc.) in conjunction with a gradual release of responsibility toward learner independence, FieldSTEM notebooks promote the development of ELA and math skills, scientific reasoning and social competency. Abstract concepts in content areas, when connected to hands-on experiences, where evidence is recorded in the FieldSTEM notebook, provide emergent readers and writers with an effective tool that allows them to increase proficiency in accessing FieldSTEM in the world around them by using ELA and math successfully. Notebooks provide a structure and support for differentiated learning, helping all students to achieve (Amaral, Garrison, & Klentschy, 2002; Gilbert & Kotelman, 2005). Strategies to help implement FieldSTEM notebooks can be found in the Appendices.

Why Learning Outdoors?

There is only one planet earth. While it sounds cliché, it is a truth that must be incorporated into our social and economic thinking. When social and economic systems are designed without thought to the effect those systems will have on the ecosystem, we do ourselves a disservice. The 2003 assessment completed by the World Resources institute says "Human well-being and progress toward sustainable development are vitally dependent upon improving the management of Earth's ecosystems to ensure their conservation and sustainable use. But while demands for ecosystem services such as food and clean water are growing, human actions are at the same time diminishing the capability of many ecosystems to meet these demands. Sound policy and management interventions can often reverse ecosystem degradation and enhance the contributions of ecosystems to human well-being but knowing when and how to intervene requires substantial understanding of both the ecological and the social systems involved."

Engineering design is the process we use to define problems, design solutions and optimize those solutions. In the National Research Council's, A Framework for K-12 Science Education (2102 p11-12) the term engineering is used "in a very broad sense to mean any engagement in a systematic practice of design to achieve solutions to particular human problems." Our economies are heavily tied to engineering design innovation. Materials used for innovations come from the earth and by using them, we affect the earth. If we hope to live in sustainable communities, we must include instruction about the natural systems from which our technology is built. FieldDesign considers technology in the broad sense similar the Framework for K-12 Science Education which states "we broadly use the term "technology" to include all types of human-made systems and processes—not in the limited sense often used in schools that equates technology with modern computational and communications devices. Technologies result when engineers apply their understanding of the natural world and of human behavior to design ways to satisfy human needs and wants." (NRC 2012, p. 11-12).

In Washington State road construction is an example of humans solving one problem and inadvertently creating another, transportation from one town to another required roads which in many cases blocked salmon passage to spawning grounds. In the building of roads, city, county, and private landowners considered how to move water under the road to prevent damage to the road, culverts were built. They did not consider whether those culverts would allow fish passage. Today, due to collaborative policy making between tribes, the state, and landowners, private landowners such as timber companies are designing culverts for fish passage, replacing those culverts and in some cases re-routing roads for fish. Counties and cities too have begun to address the problem. Our efforts to educate young people in engineering must include a consideration of the ecological impacts of that engineering.

As students increasingly grow up removed from natural spaces, experiences in the outdoors are an important instructional strategy for engaging learners in direct discovery of the world around them. This awareness of their local community can prompt a personal commitment to apply skills and knowledge in pursuit of environmental quality and quality of life. Beginning close to home, learners forge connections with, explore, and understand their immediate surroundings. The sensitivity, knowledge, and skills needed for this local connection provides a base for moving out into larger systems, broader issues, and an expanding understanding of causes, connections, and consequences.

Essential Underpinnings and Assumptions

Education is a broad field and much research has gone into the components of effective instruction. There are key foundations to effective instruction and PEI strives to embed them into our practices such as formative assessment and sensemaking for the purpose of tracking student growth and improving instructional practice. At the same time, we are mindful that current work around justice, diversity, equity and inclusion is shedding light on practices that may not show up in existing research, and which may be critical implications for many learners. Some of the practices with which FieldDesign is centered include: 1) equitable access to culturally relevant instruction, 2) integrated learning, 3) learning through the lens of locally relevant context, 4) learning that is student-centered and progressestoward student-directed as students develop their skills, 5) learning that is connected to local job opportunities and important community roles, where students interact with people from the community in those jobs and roles, and that 6) learning takes place outdoors, where ecological impacts are considered as a critical component for community decision making. We believe all students have the right to equitable, integrated, career connected, locally relevant, field-based learning - so they understand the interconnectedness of systems and can make decisions to support sustainable communities.

FieldDesign in the Classroom

FieldDesign includes components of both inquiry and engineering design. When planning how to develop FieldDesign skills, attention is paid to student capabilities in both inquiry and engineering design. Educators and students can begin their projects in one of three ways.

1. **Facilitator-selected FieldDesign:** An educator pre-selects a project, defines the problem, and facilitates the students through the process.

2. **Guided FieldDesign project:** An educator pre-selects a topic. The students work as a class with the facilitator to define a problem within the context of the topic they will all address. The educator leads a guided FieldDesign process with the students.

3. **Student-directed FieldDesign project:** An educator pre-selects a topic. Students individually or in small groups define a problem relevant to that topic and design a solution. For example, if the topic is stream health, one team may design a way to prevent erosion from entering the stream, another may focus on reducing nitrogen flow to the stream, another may reduce an invasive organism, etc. Educators act in the capacity of the facilitator and learn along with students. (Student-directed FieldDesign is fully covered in the secondary version of FieldDesign, this guide will focus on the first two methods of implementation.)

Generally primary teachers would start with a facilitator-selected FieldDesign project to provide structure for young learners. As students move into intermediate grades, teachers are encouraged to transition toward a guided FieldDesign project so that by 6th grade, students are prepared to undertake student- directed FieldDesign. Students in upper intermediate grades who have had little experience with the engineering design process should start with a guided FieldDesign project.

Engaging Students in an Engineering Design Project

There are many opportunities to engage students in authentic FieldDesign. If there is access to a local park or natural area or a site on the school campus, a visit to the site can be the starting point. Have student record their observations and questions in their FieldSTEM notebook. As the students explore the site and begin to investigate situations or phenomenon they encounter, encourage them to focus on what they observed and any questions they have about what they encountered. During a follow up class discussion, have students compile the questions and group them to determine phenomena that can be explored.

When students hear the word problem , most assume something is wrong. A problem is often defined in dictionaries as a situation in which something is at risk. Adults describe many things, including car repairs, lost keys, or injuries, as problems that need effort to be “fixed.” Often associated with a negative, it is no wonder students make that assumption!

In Engineering Design, a problem is a challenge solved through a series of steps used to design a solution. It can be solved with a solution or multiple solutions, but it has a less negative connotation. Engineering design uses a problem to frame the purpose or reason for the project students engage in. Students come to understand that a situation that people want to change or create can be approached as a problem to solve.

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What is the role of Phenomena in FieldDesign?

The term phenomena is used nationally in science education to refer to surprising, puzzling experiences that may be inexplicable, given a student's prior knowledge. Other terms that have been used to describe this idea in the education sector include "disequilibrium", "a discrepant event", and sometimes more generally as "engagement". Phenomena can serve a student in many ways; it can awaken their curiosity to motivate them to understand events, predict and prepare for events, answer questions or help them solve problems. With any instruction, a phenomenon can anchor the topic of instruction by supplying students' experience and thinking toward the challenge of explaining or solving a problem. The purpose of the anchoring phenomenon is to incite curiosity that will motivate the learner as they work toward those explanations and toward implementing solutions. When the anchoring phenomenon is used in concert with formative assessment, an educator has powerful tools to focus learning on student-centered learning.

PEI'S FIELD DESIGN OVERVIEW

STEPS

1 Identify a situation, determine and define a problem
Students use scientific information about a situation or phenomenon to define a locally relevant, field-based problem and describe a desired change. The problem is one that can be solved with the development of a new or improved object, tool, process or system.

2 Research the problem, describe the ecosystem and identify key stakeholders
Students describe the problem in the context of the local ecosystem, social system and understanding of stakeholders and then determine the projects' criteria for success and any constraints that need to be acknowledged.

3 Design solutions and develop a plan
Students plan possible design solutions and develop a plan using models to communicate intentions.

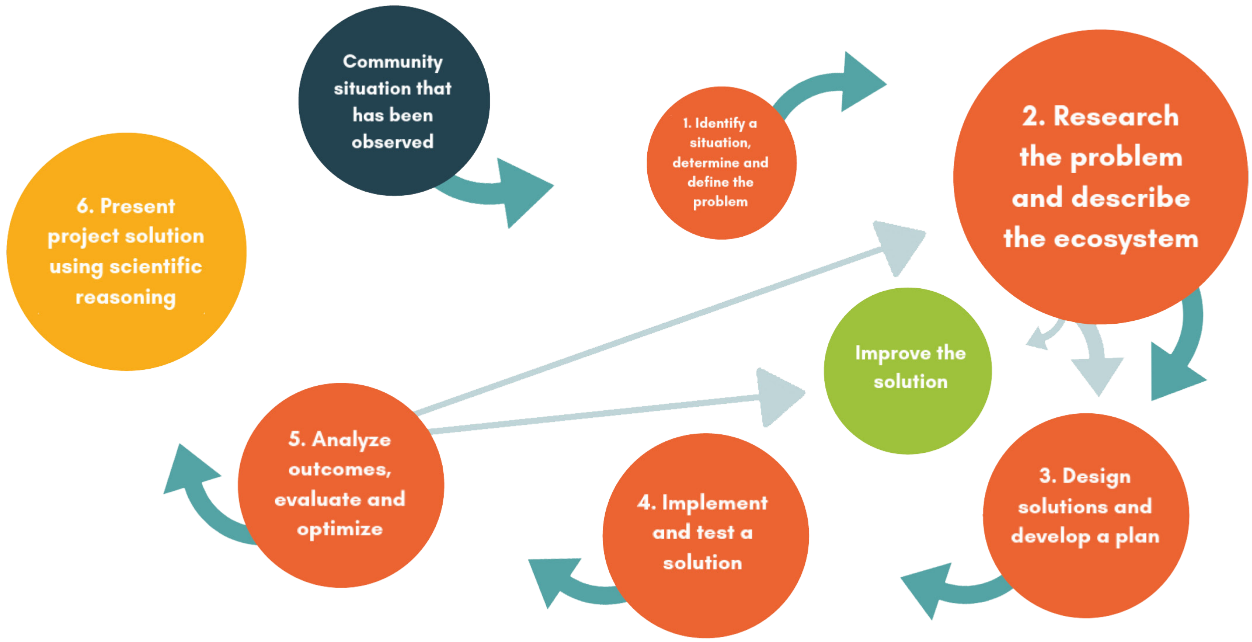
4 Implement and test the solution
Students execute their plan based on their research and design in an attempt to solve the problem.

5 Analyzing outcomes, evaluate and optimize
Students make recommendations on how to optimize the results they attained.

6 Present final solution using scientific reasoning
Students give an active and meaningful presentation of their results to their community.

1 STEP

IDENTIFY A SITUATION,
DETERMINE AND DEFINE THE PROBLEM



STEP 1

NGSS Information: Science and Engineering Practices

- Asking questions (Science) and defining problems (Engineering)
- Developing and using models
- Planning and carrying out investigations
- Constructing explanations (Science) and designing solutions (Engineering)
- Engaging in argument from evidence
- Obtaining, evaluating, and communicating information

Science and Engineering Practice: Defining Problems

Examples of outdoor phenomena - based problems:

- plant damage/disease
- extreme weather events
- ocean acidification
- phenology
- stormwater runoff
- accelerated erosion
- increasing greenhouse gases
- generating enough energy
- invasive species
- rising sea levels

When students hear the word problem, most assume something is wrong. A problem is often defined in dictionaries as a situation in which something is at risk. Adults describe many things, including needed car repairs, lost keys, or injuries, as problems that need effort to be "fixed." Often associated with a negative, it's no wonder students make that assumption!

In Engineering Design, however, the problem is a challenge solved through a series of steps used to design a solution. It can still be fixed with a solution or multiple solutions, but it has a less negative connotation. Engineering Design uses a problem to frame the purpose or reason for the project students engage in. Students come to understand that a situation people want to change or create can be approached as a problem to solve.

At the beginning of the problem exploration, have the students visit a site and begin their observations and questions in their science notebook. If a graphic organizer is needed, the O.W.L. chart can be a helpful tool. An O.W.L. chart: Observations, Wondering and Learnings, is a great way to organize student thinking.

Students can record their observations and wonderings (questions) without too much prompting. If they need prompting for observations, ask them to:

- identify living and non-living things
- ways that humans have changed the area
- describe the topography
- use their senses to gather information

In the beginning they may not have much to add to “learnings”, new information that they acquire during the process.

O.W.L.: Human Impacts on Our School Grounds		
Observations	**Wonderings**	**Learnings**

The process of continually making observations, asking questions, and reflecting on newly gained knowledge is important for learners. Throughout Step 1, students revisit the field site with their original O.W.L. chart to update previous observations and wonderings by recording their new thinking. An O.W.L. chart therefore becomes a visual model that demonstrates students’ growth over the course of the project.

It is important that young students understand there are constraints to what they know. While outdoors there will often be complex interactions that cannot be easily observed which may affect the scenario. For example, elementary students will not understand the interactions of molecules occurring at the site, when this level of understanding is incorporated, a learner will have different solutions to the problem that can’t be understood at the macro level.

For a Facilitator-selected FieldDesign Project:

Facilitators (educators) presents the problem to the class and has already pre-planned the investigation. An O.W.L. chart is a tool to engage students with the topic that can be used later as a record of student growth.

For a Guided FieldDesign Project:

If the phenomena-based problem is already identified, the facilitator works with students to share the phenomena they will study and asks questions to engage them in considering the problems they might choose to solve. The phenomena-based problem can be chosen using facilitator-created criteria such as:

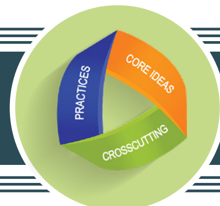
- comfort level with the number of unique team investigations
- time available to dedicate to the project resources
- topics for learning goals
- other systemic constraints

The facilitator keeps the focus on the pre-identified problem or expands it by guiding students to explore additional problems within the topic. The facilitator introduces phenomena in a way that the students grapple with it as they begin to understand how it is connected to more problems which may motivate them to engineer solutions tied to those problems.

An O.W.L. chart can also be used as a tool for classroom discussion. Further plans can then be made regarding whether the remaining steps will be carried out as a class, in teams, or other groupings.

TEACHER TIP

Because students own many of the decision-making opportunities within the process of engineering design, we are referring to teachers and mentors as facilitators. Quite often the role of the adult hosting the learning is one of facilitating student learning rather than leading students through a preset progression of learning tasks. The steps of FieldDesign can assist facilitators with understanding the learning progression students will move through and serve as a planning tool for scheduling sessions.



Next Generation Science Standards (NGSS) Information

In NGSS most learning targets are grade level specific. However, engineering standards are both embedded into specific, targeted domain standards, and are also arranged into "grade bands." The elementary grade bands are K-2 and 3-5 for Engineering, Technology, and Applications of Science. The K-2 Engineering, Technology, and Applications of Science (ETS) Standard Performance Expectations are:

- K-2ETS1-1 Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.
- K-2ETS1-2 Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.
- K-2ETS1-2 Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.

Often in K-2 classrooms, teachers support students by choosing the topic or problem in order to do "Shared Inquiry or Engineering" like ELA's Shared Reading or Writing for new or challenging content or learning processes. In this situation, the teacher would have chosen an engineering task for students to design solutions for, and the teacher would work more closely in co-designing potential solutions with students as a scaffold to their finding success with prototypes. This band fits particularly well for facilitator-selected FieldDesign.

The 3-5 ETS Standard Performance Expectations are:

- 3-5ETS1-1 Define a simple problem reflecting a need or a want that includes specific criteria for success and constraints on materials, time, or cost.
- 3-5ETS1-2 Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
- 3-5ETS1-3 Plan and carry out fair tests in which variables are controlled and failure points are
- considered to identify aspects of a model or prototype that can be improved.

In grades 3-5 students are ready to shift into more independently chosen problems, analyzing research and balancing multiple factors when deciding on possible solutions without teacher direction. The teacher will still aim student learning toward appropriate performance expectations, however, would give more freedom to students as they hypothesize solutions and work to evaluate whether they solve the problem or not.

Consider how Mr. Canon, a second-grade teacher, uses an O.W.L. chart to guide students to ask questions, observe, and gather information to help define the problem.

Mr. Canon's 2nd Grade Vignette: Facilitator-selected FieldDesign Project

Mr. Canon's second grade class has settled into their third week of school. He is developing a new unit to address the NGSS Engineering Design performance expectations (ETS-1(ETS-1, 2 and 3), 2 and 3) for his students and knows they should be embedded inside other NGSS performance expectations to give context and a deeper learning experience. The classroom is situated right next to the playground "field area," which was reseeded over the summer and a small muddy patch of unplanted dirt between two walkways outside the classroom door. As a result, the Grounds and Maintenance Department from the school district has created barriers with stakes and yellow caution tape to keep students out of the area. Mr. Canon sees this unexpected do-over as a learning opportunity for his students. He wanted to engage his students in a field experience as a launch into an already planned gardening project and now wants to use this phenomenon as a door into a FieldDesign project that focuses on proper garden planning and plant care.

Mr. Canon read several nonfiction picture books to his class that focused on plant needs and connections to their Earth and Space Systems standards. Mr. Canon chose these books to build background knowledge when designing the garden. Most students understand that water is a basic human and ecosystem need, however their attention is focused primarily on restating what they have learned instead of exploring how human "help" may be detrimental in some cases. Mr. Canon decides to ask an expert to stop by, hoping to create more awareness with his students.

Later that week, a fourth-grade teacher in the building, Ms. Jacey, comes to Mr. Canon's class to talk about her favorite hobby, gardening. She reiterates that plants usually have similar needs, however she also shares how overusing water created a problem of seed loss in her garden. After Ms. Jacey's visit, the class discussion reveals questions about how providing for a plant's need can be overdone.

Mr. Canon asked, "You've all shared some very good questions about water use and how it hurt Ms. Jacey's garden. Were any of you surprised when she shared how water caused problems for her when we know her garden needed to be watered?".

Students nod and one says, "I thought plants needed lots of water!". Mr. Canon gives time for students to talk with partners to share what they think they know about seeds and plants, and then asks them to share what they have already observed and know about plant needs. He decides to record shared observations on the class O.W.L. chart he has prepared and titles it, "Seeds and Plants."

After recording student ideas Mr. Canon shares, "I'm wondering how water made seeds go away. I know I have to water my lawn a lot, but I don't see the seeds missing or big bald patches in my yard, what do you all think she meant when she said water actually caused problems?".

The students turn and talk with partners again, and Mr. Canon calls the group together to collect wonderings for the O.W.L. chart. One student, Amelia, asks "did the water make a river that made the seeds float away?" Mr. Canon models recording Amelia's wonder on the O.W.L. chart so students may do so independently later in the project.

After more discussion one student brings up the new grass growing in the playground field, and a protected patch of dirt outside their classroom door. The discussion shifts to wonder if water may have affected the protected space, and Mr. Canon adds those ideas to the class chart under wonderings. Mr. Canon guides the discussion to remind them what they have learned from their books. He helps frame the pre-chosen problem of investigating the many variables that could have affected their plot of land by suggesting the class brainstorm what they know and then investigate that space.

Mr. Canon tells the class that their investigation will inform their FieldDesign project, growing a class garden from seeds. "It's so lucky we are investigating this," he tells his students, "Just yesterday a friend offered us some special seeds, asking if we would help create a garden that will attract animals called pollinators. After seeing what happened to our playground, I was worried that we would have problems getting the seeds to grow." The class is excited to hear they will be growing plants from seed and worried they will end up with bare patches in their garden.

Mr. Canon sets up the next day's investigation by sharing that the class will observe and compare the protected, bare spot and the areas on the playground that are not. Hopefully they will be able to fill in some learnings on their O.W.L. chart. He is still evaluating how well his new second graders write and decided to record a clear problem statement on a chart, "The Problem: How can we plant a garden so most of our seeds grow and attract pollinators?" rather than have students record it themselves. He will then ask the class, "Why is this a problem? Does it matter that we might lose some seed?".
He will record replies under the heading "Why is this problem important in real life? What happens if no changes occur?" .Mr. Canon is using the facilitator-selected project model; he has set the scene for exploring garden preparation challenges and irrigation issues to guide students while tying it to a local phenomenon that they can experience firsthand. Although the goal is to have students take responsibility for as much of the work and recording as possible, he has chosen to scaffold the project to support their learning of the process of engineering design. He purposefully did not offer the students opportunities to select other problems to investigate so the entire class is learning the steps of the process together.

TEACHER TIP

For early learners, there are times, whether dependent on developmental level, or time of year, that accommodations and differentiation may be necessary for steps described as writing tasks. What is most important in FieldDesign for primary students, or those needing accommodations, is that they access the thought process and communication of understanding. Some potential ways to differentiate based on student needs are:

- draw pictures or models of observations
- dictate observations or thinking to a "scribe"
- use speech capturing technology, or technology to produce artifacts of learning
- scaffolded journal starters with blanks for filling in key words

Ms. Ramirez's 5th Grade Vignette: Guided FieldDesign Project

Ms. Ramirez's fifth grade class has been studying Earth's systems, and how the atmosphere and hydrosphere interact through a unit called "Water, Weather and Cycles." They have been learning about ecological challenges while studying the causes of acid rain. Students begin expanding into deeper global discussions about problems which would require political action and begin moving toward a "we are just kids; adults make the decisions" mindset. Sensing her students' need to impact change, she decides to frame their work around human impacts and ways communities use science to protect the Earth's resources and environment. Ms. Ramirez decides to focus on the school grounds - –n area that students could create solutions and have an impact. She hopes to broaden their perspective on the Earth's interactive systems to include the geosphere and biosphere and believes the motivation students have shared in their last unit will carry forward into this unit.

The class takes an "impact walk" around the school grounds, tasked with observing and recording potential human impact problems the class could investigate. The class will utilize individual O.W.L. charts. Some students note litter concentrated in areas around the baseball backdrops, others observe dirt and mud trails being created on sports fields where foot traffic is high, and a few are drawn to the boundary fence of the school grounds where a new housing development is being built on the other side. The fence has been built close to mature trees where students observed birds when they were in fourth grade. The students note they don't see birds now, and about three-fourths of the trees have been removed for the construction.

When the class returns to their room to discuss their findings and choose a problem, not all students agree which one to pursue. Ms. Ramirez quickly realizes she will need to decide whether to require the class come to consensus on one problem or if she would allow for groups to investigate multiple problems and projects around human impact on school grounds. She realizes that she will want to post the problem(s) so students will keep work times focused on finding a solution. The group pauses to brainstorm wonderings while she considers next steps.

TEACHER TIP

Based on the facilitator's comfort, and the experience students have with the process of engineering design, the facilitator may want to begin with "facilitator-selected FieldDesign" and then progress toward "guided FieldDesign". When a facilitator wants to allow for more student choice, they would use the model of "guided FieldDesign". In this model, students collaborate in small groups to evaluate the group's O.W.L. notes to determine a problem and design a solution.

O.W.L.: Human Impacts on Our School Grounds		
Observations	**Wonderings**	**Learnings**
litter on baseball field erosion trails on sports fields where kids walk neighborhood construction is right up to our playground fence, big old trees are removed less birds this year	Why aren't people using trash cans? School rules say we aren't supposed to eat at recess, how is food trash getting out there? Why do we have a pattern on how people cross the field? Why don't people follow the same path across the field? Is there a way to paint walking paths around the field? What kinds of birds are found in this area? Will the trees that are gone be replaced? Did birds nest in the trees? Isn't there a law on cutting old trees down? Are there really less birds, or is this just one day where we think we notice fewer?	

In Guided FieldDesign, if a group cannot choose one problem, further research and observations outside may be necessary. If students end up choosing multiple and varying problems to tackle within the topic, the project would be an example of student-directed FieldDesign which is more common in sixth grade and above Or, as in Ms. Ramirez's case, a facilitator decision must be made in order to continue the pace of learning. Using examples from above, she could synthesize students' questions about human impacts to pick which problem they want to address:

- Why are trails being created in the grass fields (which could involve students observing traffic patterns)?
- Is watering creating seed loss (investigating irrigation on the field)?
- Have the number or type of birds in this area changed (researching bird habitat needs)?

This process is a useful strategy when students fail to identify problems. Having the ability to consider the suggestions of their peers may be more inviting than assigned topics.

Once the problem(s) have been chosen, they can be defined as a problem statement and recorded in the students' science notebook, using the "Research the Problem" document as a template. Ms. Ramirez has decided that the perceived decline in birds, connected with new neighborhood construction, gives the best opportunity for multiple projects students can use to engage with community collaborators. Because she decided to allow multiple FieldDesign projects, she will demonstrate how to define the problems within this topic. She will use the "Researching the Problem" prompts to record discussion highlights and show individual note-taking expectations. She will ask the students to transfer these notes to their science notebooks. She's releasing responsibility to her students to brainstorm what they need to know, where they can find information, and take notes on what they discover.

Researching the Problem

Use these prompts to guide students as they gain a deeper understanding of the problem.

In one sentence, describe the problem you're planning to solve:
Why have bird populations declined recently in our area?

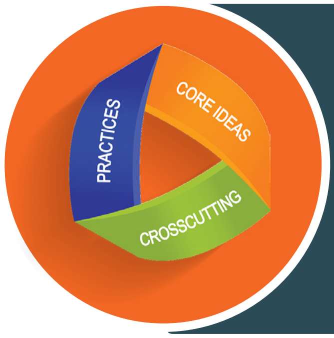
1. Why is this problem important? What will happen if no changes occur?
   It appears like we have fewer birds living on the east border of our school campus, where a new neighborhood is being built. Many large trees have been removed. We know that some birds nest in trees, and don't want a negative human impact to their habitat. If we do not find a solution, they will either have moved to a new area or could be declining.
2. What I already know that may help:
   Some birds nest in trees.
   Birds use nests for habitat and to lay eggs in a protected space.
   Some birds find safety from predators by flying into branches.
   Some birds may eat seeds in cones or branches.
   The noise from construction could be scaring wild animals away.
   We have heard that there are laws about cutting down trees for construction.
3. What I need to know before starting:
4. Where I might find information (books, websites, experts, etc.):
   My notes (cite your sources):

After students research, their understanding of the problem may have changed, and a new problem now needs to be defined.

1. The problem (complete sentence):
2. Criteria (goals):
3. Constraints (limitations):
4. What I know now that may help:

2 STEP

RESEARCH THE PROBLEM,
DESCRIBE THE ECOSYSTEM AND IDENTIFY KEY STAKEHOLDERS



NGSS INFORMATION:
SCIENCE AND ENGINEERING PRACTICES

- Asking questions (Science) and defining problems (Engineering)
- Planning and carrying out investigations
- Engaging in argument from evidence
- Obtaining, evaluating, and communicating information

In step 1, students identified and defined the problem(s) they will address in their FieldDesign projects. In step 2, students will research how ecosystem components and key stakeholders could play a role in their FieldDesign investigation.

In step 2, groups of students will determine what they already know and what they still need to learn through research and investigation. They can refer to their O.W.L. charts and "Researching the Problem" document to guide their note-taking. Students also begin to generate a list of information and resources they will need to gather before designing solutions.

In both facilitator-selected and guided FieldDesign, the facilitator role is to encourage students to take charge of their learning and equip them with tools and resources to support success. Grade level appropriate researching, collaboration and questioning skills from English Language Arts can be helpful in this step. This may mean more of a shared approach in K-2, or beyond, if these skills have not been developed. The facilitator offers guidance as students search out information, address reliability of sources, refine their questions, and connect with experts if possible; all practices that "professional scientists" use.

What planning and teaching strategies has Mr. Canon prioritized to assist his researchers in collecting important information?

Mr. Canon's 2nd Grade Vignette:
Facilitator-Selected FieldDesign Project

"It seems to me," Mr. Canon says the following day while referring to the class O.W.L. chart on seeds and plants, "that we already know a lot about the conditions plants need to survive, and we are wondering about what may interfere with seeds growing into plants. Today we will go outside to observe our future garden patch and other playground areas with plants growing to gather data that will help us design our class pollination garden".

Mr. Canon uses the class O.W.L. chart from their previous site visit to update their observations and learnings while outside. As the class observes the muddy patch, they note that some seedlings are already successfully beginning to sprout, while most of the area remains bare. Students also make observations of uneven soil levels, a small puddle from sprinkler runoff, and a clump of grass that has begun growing in the corner of the space. Mr. Canon lists these on the class O.W.L. chart. Mr. Canon leads the group to a playground space with more diverse plants growing successfully, the kindergarten vegetable patch. He distributes fresh O.W.L. charts to pairs of students (science partners) to collect observations about the new site.

TEACHER TIP

Use partnerships that have already worked in the classroom where the students work well together. Limiting time for observations can help keep students focused while outside.

"OK everyone," Mr. Canon says. "We just saw some things that may have affected seed growth in our future garden spot. I'd like you to keep these in mind as you observe the spot where plants are growing pretty successfully. Science partners will need to describe this spot in the observations column of your O.W.L. chart. We will use that data to plan for a successful garden. "Let's see how many observations you and your science partner can record in ten minutes. Begin!".

After this activity is finished and the class returns inside, Mr. Canon facilitates an observation sharing session. The emphasis should be on the things they observed, not assumptions about the causes of their observations. The observations shared included:

- a few weeds, ants, a spider, fir cones, less rocks, a footprint, uneven soil
- a hose spigot nearby
- darker soil than the future garden patch
- mounded dirt circles around the base of some plants

Once the observation sharing is finished, Mr. Canon asks partners to discuss and record three wonderings. He reads a book next to the vegetable patch to introduce and deepen understanding of pollinators to the class, and a quick article from a children's news blog explaining that some pollinators' survival is threatened due to decreased habitats. This will guide the urgency in their project.

Then, Mr. Canon uses a class Researching the Problem chart based on the students' notes in their O.W.L. charts.

Researching the Problem

1. **In one sentence, describe the problem you're planning to solve:**
   We are creating a garden where seeds will grow successfully but wonder if the space will be healthy for our seeds.
2. **Why is this problem important? What will happen if no changes occur?**
   Animals depend on plants for food, and plants depend on animals sometimes for pollination and survival. We know that some pollinators are struggling to survive and want to help them with our garden.
3. **What I already know that may help:**
   We can help pollinators by growing more habitat for them.
4. **What I need to know before starting:**
   Is the space we have for planting a pollinator garden good enough to support the seeds and plants with enough sunlight, water, and correct soil conditions?
   Do spiders or ants harm seeds?
   Will enough sunlight hit our garden?
   Will rain from the roof splash our seeds and make them run out of our garden?
   Do we have permission to use a hose to water our garden?
   Can we use tools to make the soil ready?
5. **Where I might find information (books, websites, experts):**
   books, websites, gardeners, family members, the Principal

   My notes (cite your sources):
   After the students complete their research, their understanding of the problem may have changed.

   1. **The problem (complete sentence):**
   2. **Criteria (goals):**
   3. **Constraints (limitations):**
   4. **What I know now that may help:**

TEACHER TIP

The problem statement is used as a starting point to develop an understanding of the characteristics of a good solution. These characteristics are described in terms of constraints and criteria. A constraint is a limitation or condition that must be satisfied by a design. A criterion is a standard or attribute of a design that can be measured. The constraints and criteria are used in subsequent steps of the design process to determine which of many possible designs should be implemented.

Mr. Canon has supported his second grade students by showing them how to use recording tools before asking them to do so on their own, and has slowly introduced them to his facilitator-selected FieldDesign project by anchoring student understanding through observation and by modeling research using various texts to learn how to successfully grow grass on their playground. He also encouraged the students to consider the criteria for success (e.g. the plants grow, and pollinators use them) and constraints they have (e.g. the class has been given permission to use a certain space for their garden, they are working with the donated seeds).

Stakeholders: In step 2 students begin to build an understanding of stakeholders; anyone with interests related to the problem or outcome. Stakeholders have a vested interest in the area or resource identified in the problem, or are responsible for funding, policy, decision-making, and laws pertaining to potential solutions to problems. While students do not need to honor every concern of each stakeholder group, they do need to seek approval, funding and/or land access from key stakeholders to carry out a solution. In the example of a pollinator garden, facilities personnel and the school principal will have to be involved at a minimum.

While students research stakeholders connected to their project, they learn about multiple viewpoints in relation to problems and potential solutions. One solution may impact a group of stakeholders or their interests negatively, which could create barriers to student solutions. Students should research at least 2 stakeholders by contacting local tribes, business and industries, community groups, landowners, and local, state and federal governments. This could be via personal interviews, newsletters, or website research (the stakeholders' primary site, not third-party sites that may include biases not shared by the stakeholder). The key is that students research and share what they've learned with other students, so solutions address key values and potential points of contention of the groups.

Mr. Canon's class completed a Stakeholder Research document after meeting with their principal about the pollinator garden.

Stakeholder Research

Stakeholder points of view are important to understand before planning solutions.

Stakeholder name (individual, organization, business, agency):

Stakeholder website: School District Facility Decision Maker

Contact phone number/email: Office (555) 555-0100

Contact name: Mrs. Galvinez (the school principal)

How is this stakeholder connected to the problem?
Mrs. Galvinez gives permission for special projects at our school. It is her job to make sure that what happens at the school is good for the whole school and for learning.

Is the stakeholder aware of the problem? If so, what are their opinions about it?
Mrs. Galvinez said that Mr. Canon has talked with her about the garden already. She did not know all the facts we shared about how pollinators need our help and was more excited to give us permission to use garden tools to make the space ready after hearing about it.

If the stakeholder owns land where the project would take place:

- **How do they currently use the land?**
  It is an empty space not being used now
- **Does that use of the land impact the problem? If so, how?**
  We need this space, without it we cannot help pollinators
- **Are they trying to be environmentally-friendly? Explain.**
  She is not using it right now and wants to be environmentally-friendly
- **Are there laws that affect the way the stakeholder can use the land?**
  There are school district rules about changing school property and principals can give permission for gardens
- **Are there any culturally or familial connections that ties the stakeholder to the land?**
  No

How could the problem affect the stakeholder now and in the future?
Mrs. Galvinez might not want us to plant if we cannot promise to take care of the garden. If we do not take care of it, she may not have time to, and the garden would die.

How could the stakeholder contribute to the problem?

How could they be part of the solution?
We can invite her to help us care for the garden. We can ask that she talk with the maintenance team (groundskeepers) to make sure they don't pull out our plants out because they think they are weeds.

Would the stakeholder like to play a role in this project? If yes, what role?
(For example, speaking to the class or providing resources) She says she supports us, but would like it to be our responsibility. She will make sure that no workers pull out our plants and says we can bring a hose or watering can to water our garden when there is no rain.

Would the stakeholder be interested, financially, in finding a solution?

How is Ms. Ramirez guiding her students to include stakeholder perspectives as they research potential solutions and challenges?

Ms. Ramirez's 5th Grade Vignette: Guided FieldDesign Project

After initial research and deliberating as a class, the students are learning about local bird habitats and human impacts on them. Small groups of students have chosen different subtopics they need to know more about to approach the problem, decided on where to find the answers, researched and summarized what they learned on their Researching the Problem document, and presented findings to the class. Ms. Ramirez sent an email to the construction company and learned that local construction laws require only a certain percentage of trees must remain on property that's being developed. They also learned that because the property is not owned by the school district, they cannot ask their principal (and district) to replace the trees for the birds. The construction company, (Winthrop) has left more trees than required by law on the property and feels good about that choice. Student discussions lean toward feeling helpless with this problem.

"Ms. Ramirez, if they don't have to change because they followed the law, then what can we do?" a dejected boy, Xavier, asks.

Ms. Ramirez replies, "Well, are there any other adults we can think of who would be interested in helping us understand bird habitats, even if the new landowner does not have the same concerns we do?".

The class goes quiet for a while, and then Xavier shares, "My grandma loves bird watching. She names them all the time when I visit her. I wonder if she knows who can help us?".

"Good thinking," Ms. Ramirez responds. "Does anyone else have family members that enjoy bird watching? They may have ideas of organizations or clubs who would be interested in helping us. They may have already worked through some barriers we haven't thought of or have experiences that can help. We call those interested people 'stakeholders.' It's important we look at many sides of this issue if we want to solve this problem.".

Ms. Ramirez explains that having questions ready in advance will help. The class works on completing each student's Stakeholder Research document with the information they received from the construction company, and answer the questions together based on what they know. They will complete a second Stakeholder Research document based on what the three students' family members share from the evening's phone calls.

Stakeholder Research

Stakeholder points of view are important to understand before planning solutions.

Stakeholder name (individual, organization, business, agency):

Stakeholder website: Winthrop Construction Company

Contact name: T. Winthrop

Contact phone number/email: 555-010-1357

How is this stakeholder connected to the problem?
Winthrop Construction is building the neighborhood next to our school. During construction they removed some of the tall, old trees that we assume served as habitat for local bird species. They own the land where they are building.

Is the stakeholder aware of the problem? If so, what are their opinions about it?
Yes. We shared the problem with them, and they said this is a common concern whenever construction projects begin in an area with large trees. Winthrop Construction shared that they are aware of local laws around tree removal, and actually work to remove as few trees as possible. They also shared that they have removed fewer trees than they are legally allowed to for this project and feel they have done all they could do while moving forward with construction so that more local families have affordable housing.

If the stakeholder owns the land where the project would take place:

- **How do they currently use the land?**
  It is a neighborhood construction site.
- **Does that use of the land impact the problem? If so, how?**
  Yes, decreased trees most likely means less habitat for our local birds.
- **Are they trying to be environmentally friendly? Explain.**
  Yes, they said they only remove what is necessary and have done better than local laws require.
- **Are there laws that affect the way the stakeholder can use the land?**
  Yes, see above.
- **Are there any culturally or familial connections that ties the stakeholder to the land?**
  Yes, they are a local family and want to do what's best for our local economy.

How could the problem affect stakeholder now and in the future?
Winthrop Construction tries to balance what the community needs (housing) with environmental needs (animal habitats). If the community does not agree with their building practices, they could lose local tax support and lose housing sales. But, if they try to preserve more habitat space, they will not be able to provide more housing for the people in our community.

How could the stakeholder contribute to the problem?

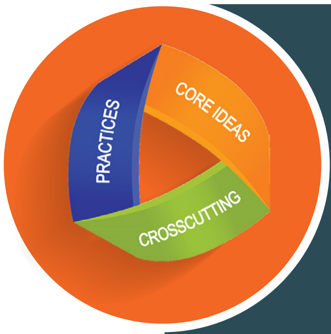
How could they be a part of the solution?
We could ask if they are interested in learning more about how to provide replacement habitats so that they can meet their business needs and help with habitat needs.

Would the stakeholder like to play a role in this project? If so, what role? Right now, they say they are busy with construction, but maybe we can invite them to partner after they finish their project.

Would the stakeholder be interested, financially, in finding a solution?

3 STEP

DESIGN SOLUTIONS AND DEVELOP A PLAN



NGSS INFORMATION: SCIENCE AND ENGINEERING PRACTICES

- Asking Questions (Science) and Defining Problems (Engineering)
- Developing and Using Models
- Constructing Explanations (Science) and Designing Solutions (Engineering)
- Analyzing and Interpreting Data
- Engaging in Argument from Evidence
- Obtaining, Evaluating, and Communicating Information

Often students identify problems on school grounds that are not new. Knowing the history of the problem, what's already been tried, and the results of that solution can be of great value. These may have been addressed a few years ago and the solution wasn't sustainable.

Students can research and evaluate ideas that others have proposed, and actions previously taken or record original ideas. Using the Solution Analysis document will help scaffold discussions, focus "best plan" argumentation, and eventually narrow plans down to one proposed solution. Students will most likely find multiple solutions to a problem, each with its own set of benefits and consequences.

The following is an example of Amelia and Nevaeh's Solution Analysis and Solutions Comparison table with their original ideas from Mr. Canon's classroom:

Name: Amelia and Nevaeh Date: 10/2

Solution Analysis

You are ready to brainstorm possible solutions to the problem! Others may have tried to solve this same problem in the past. Research what solutions have been tried. This information may come from your stakeholder research or from new information you have gathered.

You may also have some of your own ideas of possible solutions. Each possible solution will have its own set of positive impacts and negative consequences. To decide the best possible solution to the problem you chose, follow this process with each solution you learned was already tried and those you have developed.

Create a list possible solutions. Write down all the possible solutions you learned about during your research as well as your own ideas:

- ~~Dig out all the dirt and start with fresh potting soil that controls weeds and watering.~~
- Mix water and weed control potting soil in our garden. Don't have to take away other soil.
- ~~Install sprinklers so we can put them on a timer and control the water.~~
- ~~Have every kid take a turn watering and weeding on weekends and during summer.~~
- Make the garden one of our classroom jobs.
- Build a fence and put a net over the top so people and birds cannot bother the seeds.

1. **Narrow your list down. Cross out any ideas that don't seem realistic or do not interest you.** (Keep in mind that just because some projects will require money and/or experts this does not mean the solution is unrealistic. Groups and
2. businesses are often willing to donate materials, their time or funds to help students with projects)

3. **Choose your top 3 solutions. You will start by analyzing only these 3 in order to decide which one you plan to complete.**

4. **Compare solutions using the Solution Comparison Table.**

5. **Choose the best solution for your project based on the Solution Comparison Table and share your choice with your teacher to get**
6. **approval for your project.**

After comparing and analyzing lists of potential solutions, students move into using the Solution Comparison Table to analyze their group's top possible solutions. This could be done in their science notebooks, distributed as a copy of the table to be taped inside their notebooks, or part of a packet the teacher has created.

SOLUTION COMPARISON TABLE

Possible Solution Summary	Criteria for success and positive impacts	Potential negative consequences	Stakeholder thoughts	Constraints that may make this difficult	Is the plan reasonable?
Who was/will be involved in the project? What did/will they try? How did/will they go about their solution? When was/will this be? Where was/will this be?	What positive impacts on the environment could come from this solution?	What results of this solution could be harmful?	What might stakeholders like or dislike about this solution?	Consider time, resources, liability, etc.	Rank how likely it could be completed: 1 = low 2 = Medium 3 = High 4 = Certain
1. *Use a potting soil designed to retain water. We can ask for donations from a garden shop and get it turned into our existing soil this fall, ready for spring planting.*	oil will be ready for our seeds so that they grow healthy. Pollinators would like our garden and we would be helping them.	The insects and spider that already live here may not like it.	It might make the dirt muddier. They may not like the looks. They might worry about students tracking mud inside the building.	Money for the soil. Tools needed to get it blended with the dirt already there.	4
2. *Mr. Canon can make the garden one of our classroom jobs. Our jobs are set every week, he would keep track.*	Our garden would be cared for every week. Weeds would be small and easy to pull. Weekly check in would mean we would know about problems before it's too late.	If someone doesn't do a good job, the next person has more work. Our garden could die.	We think Mr. Canon would like this since he's in charge of our garden project already. He likes when we share and help each other.	When we go on vacation this will be hard.	4
3. *We can have adult volunteers help us build a fence and stretch a net over the top this spring, after we plant seeds. They can bring the tools and we can ask for materials donations or Mrs. Galvinez.*	It would be a warning not to stomp our garden to stay out.	Maybe it could block rain or make watering harder? If we do not clean up scraps from building it could be dangerous.	School people will like it better than mud. Others might not like how it looks. People walking past the fence might not notice it and get their legs scraped.	We cannot let people get hurt. We might not have adult volunteers with tools. We might not be able to get materials donated.	2

TEACHER TIP

Some students may research and brainstorm solutions at a pace that does not match that of their peers. To ensure all students can record their ideas, plan enough time for students to finish and ensure the students that finish early have a productive activity to engage in allowing slower students time to contribute.

Through this process students gain a perspective that each action has potential reactions, both positive and negative, and that multiple perspectives and factors need to be considered when deciding if a potential solution can be successful.

What does Mr. Canon use to capture science partner thinking before it’s lost, while keeping the pace moving with his class?

Mr. Canon’s 2nd Grade Vignette: Facilitator-selected FieldDesign Project

“Alright everybody, you and your science partners have completed your Solution Analysis pages and narrowed down the best choices for the class to consider. Now let’s compare what’s left by considering our criteria, constraints, and how likely a solution is to work. After this, we will make our choice for our class project. Here is how we are going to work through this...”

During the last 15 minutes of class, partners share their highest rated solutions while Mr. Canon compiles them into a class data table for consideration. Mr. Canon projects the Solution Comparison Table so that students work as a class to evaluate the selected solutions.

SOLUTION COMPARISON TABLE

Possible Solution Summary	**Criteria for success and positive impacts**	**Potential negative consequences**	**Stakeholder thoughts**	**Constraints that may make this difficult**	**Is the plan reasonable?** Rank how likely it could be completed: 1 = low 2 = Medium 3 = High 4 = Certain
1. *Use weed and water control potting soil. We can ask for donations from a garden shop and get it turned into our existing soil this fall, ready for spring planting.*	We would use less water It would look prettier Increase habitat for pollinators Other classes may want to start projects because they see ours	Organizing care for the garden If bees sting students If people pick our flowers	Some students are allergic to bee stings. If a student gets strung it could be 911 People like colorful plants	Summer watering and weeding Vacation watering and weeding When it’s rainy in winter, will we really go out to care for garden? Will it get overgrown with weeds?	3
2. *Mr. Canon can make the garden one of our classroom jobs. Our jobs are set every week, he would keep track.*	We would learn responsibly Mr. Canon already has classroom jobs, this would be easy to add just one more	If somebody says they don’t want to help If somebody does a bad job and our garden dies If somebody accidentally weeds out a plant, we want	Mr. Canon like to teach us responsibility. Mr. Canon might not like to remind us to go to the garden.	If Mr. Canon is sick he might forget to tell the substitute to remind us. Not all of us might be good for this job.	4
3. *We can have adult volunteers help us build a fence and stretch a net over the top this spring, after we plant seeds. They can bring the tools and we can ask for materials donations or ask Mrs. Galvinez.*	It will help our seeds get a good start with growing. It will warn others to stay out of the garden. Adult volunteers like it and want to keep involved and that would help us keep it going.	We may not get volunteers to help us. The netting may rip or tear, and we would need to replace it. We might not get donations of materials.	Volunteers may not want to fix things that they already worked hard on. People may not want to donate materials. Maybe they did one time before and those kids didn’t take care of it?	Cost of materials Cost of replacement materials Time with volunteers that matches our classroom schedule	3

The final part of Solution Analysis is having students decide on the one plan they would like to develop and defend (argue with evidence) the reasoning behind their decision.

This is a good opportunity for the teacher to gain understanding of the class's thinking and priorities and to give approval (or not) before students begin the work of planning their project.

Grades 3-5 should move to more independence with evaluating whether potential solutions will meet criteria for success and constraints.

TEACHER TIP

There are both pros and cons to having groups begin collaborating right away to construct lists of possible solutions together. To ensure introverts are part of the conversation, consider giving individual think time for students to synthesize past research and begin listing an idea or two to present to their group. Some teachers insist that at least a part of each teammate's ideas is included in their group plan and at the least, the team should have consensus.

How has Ms. Ramirez scaffolded what she asks students to do in order to move their thinking to this place?

Ms. Ramirez's 5th Grade Vignette: Guided FieldDesign Project

The fifth-grade class has been researching and sharing in order to build an understanding of stakeholder perspectives. Teams, based on student interest, begin creating plans that may solve the problem. Here is one team's Solution Analysis around building birdhouses to increase bird populations.

Name: Xavier, Jacob, Delilah, Maricella Date: 9/29

Solution Analysis

You are ready to brainstorm possible solutions to the problem! Others may have tried to solve this same problem in the past. Research what solutions have been tried. This information may come from your stakeholder research or from new information you have gathered.

You may also have some of your own ideas of possible solutions. Each possible solution will have its own set of positive impacts and negative consequences. To decide the best possible solution to the problem you chose, follow this process with each solution you learned was already tried and those you have developed.

1. **Create a list possible solutions. Write down all the possible solutions you learned about during your research as well as your own ideas:**
    - Get materials to build birdhouses to install on the fences near where trees used to be.
    - Learn about improving bird habitat and plant things that will help provide bird habitat.
    - ~~Plant large trees on our side of the fence to replace habitat lost.~~
    - ~~Place birdhouses on poles in our playground to simulate high safe spaces.~~
    - ~~Ask builder for scraps to build nesting boxes.~~
    - Add birdhouses to the sides of our school, up high where they won't be disturbed.
2. **Narrow your list down. Cross out any ideas that don't seem realistic or do not interest you.** (Keep in mind that just because some projects will require money and/or experts this does not mean the solution is unrealistic. Groups and businesses are often willing to donate materials, their time or funds to help students with projects)
3. **Choose your top 3 solutions. You will start by analyzing only these 3 in order to decide which one you plan to complete.** Each possible solution will have its own set of positive impacts and negative consequences.
4. **Compare solutions using the Solution Comparison Table.**
5. **Choose the best solution for your project based on the Solution Comparison Table and share your choice with your teacher to get approval for your project.**

SOLUTION COMPARISON TABLE

Possible Solution Summary	Criteria for success and positive impacts	Potential negative consequences	Stakeholder thoughts	Constraints that may make this difficult	Is the plan reasonable?
Who was/will be involved in the project? What did/will they try? How did/will they go about their solution? When was/will this be? Where was/will this be?	What positive impacts on the environment could come from this solution?	What results of this solution could be harmful?	What might stakeholders like or dislike about this solution?	Consider time, resources, liability, etc.	Rank how likely it could be completed: 1 = low 2 = Medium 3 = High 4 = Certain

Possible Solution Summary	Criteria for success and positive impacts	Potential negative consequences	Stakeholder thoughts	Constraints that may make this difficult	Is the plan reasonable?
Get materials to build new birdhouses and install birdhouses on our fences, near where trees used to be.	By hanging birdhouses near where birds used to nest, we hope those local birds won't have to leave the area. We know that even one shift of species in an ecosystem can affect all the others in the food web and local ecosystem health. By recycling materials, we will help the birds and also help decrease our landfills.	If we don't hang birdhouses correctly, we could damage the school fences and birdhouses may fall with nests inside. Some recycled materials may not be healthy to use for bird habitats. Some materials may be more noticeable and invite predators to attack nests.	Hanging birdhouses on existing fences means we don't have to disturb any playground space for other students or our grounds workers. School staff and families may be happy that we are trying to have a positive influence on local habitats. Some people may not like the new houses hung on the fence because it looks "less clean."	Students can sign up to pick up materials needed for new habitats so that, after we meet with ornithologists, we can determine birdhouse requirements for the bird species that live in the area. This might be expensive, or families may not want to drive students to go pick up materials. Parents would need to get permission notes to drive other students in their cars.	5
Ask ornithologist about what birds need and plant things that will help provide bird habitat.	By working with ornithologists, we will learn which types of habitat are most helpful to our bird species, as well as what placement will help them the most. We want to make the most informed decisions to help our ecosystem.	If the ornithologists tell us not to create substitute habitats, our project will be cancelled. Some plants are not good for this area. It may take too long for the plants to grow and the birds may leave.	The ornithologists may be happy to have us helping or may worry we will mess up how to support our homeless birds. Birds will be happier if they have more to eat.	If the ornithologists say we have to use plants, we cannot afford or find. If the ornithologists are too busy to meet with us.	4
Add birdhouses to the sides of our school, up high where they won't be disturbed.	Birds that like to nest high in a box will have a place to nest.	The bird house may be hard to keep clean	The building managers may not like a birdhouse on the building. Ornithologists may tell us that there aren't birds that will use the nest.	The time to collect the correct materials may slow down the project.	3

After a solution has been selected by each team, it is time to create the plan for the project they will undertake. Students will identify and list the resources needed, the steps to implement the plan, and predict the potential outcomes. Although some of this information was part of the Solution Analysis, students may determine further research will be necessary.

Students begin a new page in their science notebooks titled "Project Plan." The first part of the plan should address the project's purpose, including a description of the situation and how the project will solve the identified problem. The next part of the plan should address the ecosystem impacts including the location, describing the interconnectedness of living and non-living parts of the ecosystem. Students should address any pros and cons that may have surfaced when they interviewed stakeholders. Students then write a summary that describes what will be engineered to solve the problem, and how the solution will impact the ecosystem, human and non-human components. Students then create a table of resources needed and identify costs/donations. The table should include materials needed, volunteer time, ongoing maintenance, etc. Next, students write the procedures (step by step) and the timeline for their project, including dates for each step if possible and who is responsible for each step. Constraints should be listed, and students should consider how they will address them. Students determine the criteria for evaluation and how they will measure the success of their project. And finally, project contributors should be listed.

TEACHER TIP

In facilitator-selected FieldDesign projects, creating a plan can be done as a class. In a guided FieldDesign project, the idea is to release plan creation to student teams. Facilitators may need to model this process for the students to support their success.

Name: ____________________________ Date: ____________

Project Plan

Use details from the Solution Analysis (and any additional information gathered through research) to create a project plan.

1. Purpose: What is the problem you are trying to solve?
2. Ecosystem Impacts: Where is the problem? Be as specific as you can. Describe how this project connects to the surrounding ecosystem. How could it have positive and negative impacts?
3. Summary: In a few sentences, summarize your project and include how it will solve the problem and impact the ecosystem.
4. Table of required resources:

Resources needed:	Source:	Cost or donation value:

Total cost of the project:

5. Procedure and timeline for your project. Include dates for each step if possible and who in your team is responsible for the step. Keep in mind any further research and/or investigations you will need to complete. Include time to evaluate and possibly adjust your project plan during the process.
6. Constraints: What might cause problems or interfere with your project? How will you prepare for those limitations or challenges?
7. Evaluation: How will you measure your project's success and prove it turned out like you want and it to? Make a list of criteria that you will use to evaluate the outcomes, including measurements.
8. Project contributors: List all contributors for this project, including project teammates, experts, and stakeholders.

Name	Title/Job	Organization	Email	Phone Number

9. Project Reflection: Reflect on your project and answer the following questions.
   - What is your individual role in this project?
   - What excites you about the project?
   - What worries you?

Notes:

As students gain comfort with their role in the process of FieldDesign, Mr. Canon begins releasing decisions and responsibility to his students. He guides their decision making to include evaluating how successful they are when implementing their new solutions. How has facilitating this discussion helped students consider self-evaluation?

Mr. Canon's 2nd Grade Vignette: Facilitator-selected FieldDesign Project

During the last 15 minutes of class on the previous day, partners shared their highest rated potential solutions which were then compiled into a class data table for consideration today.

"We had lots of good thinking and suggestions on possible solutions to solve our problem of needing constant care for our plants so they will grow successfully. When I placed all your ideas on our class data table, most people scored "make plant care a class job" as a high priority, and that the group would prefer only people who are really interested in plant care would do it. So, I'm wondering how that would work since we take turns with all jobs in our classroom? Who has an idea?"

Students hold a discussion and a decision is reached that it would be treated as a volunteer job, and reminders would be given to those who signed up. Mr. Canon agrees that this is an easy routine to adopt.

Mr. Canon decides to frame student thinking using the Project Plan. "Class let's think through this systematically, like scientists. We had a constraint with the garden space, it will need watering. After we investigated potential solutions, the class mostly agreed that having a list of volunteers to take on watering during classroom job time. We know that our choices will have positive and maybe negative impacts. So, let's think through those!".

Mr. Canon creates a T-chart with + and – labels above columns, and students brainstorm positive and negative impacts. The group focuses on the negative impacts (e.g. overwatering could cause mud or erosion, etc.) and decides that part of being a garden volunteer is to be aware of and try to limit them.

"How will we remember and know if we are limiting our negative impacts?" he asks the class. They devise a short checklist for volunteers to read prior to watering, and a quick self-assessment for volunteers to complete after watering. The volunteers decided to place this "checklist" on a clipboard hanging by the exterior door, volunteers agree to sign their names and self-assess after completing their day. Mr. Canon also encouraged them problem solve challenges such as absent volunteers or inclement weather. Lastly, Mr. Canon asked volunteers to write on an index card what they were excited about with this job, and if they had any worries that he could process with them individually.

Mr. Canon worked students through the Project Plan thought process without requiring the written recording of their discussions and thoughts. This may apply to any grade level, or any student if accommodation would help them access the necessary thinking and learning.

Ms. Ramirez's class groups have been given the responsibility to design their Project Plans according to what they prioritized on their Solution Comparison Tables. How does she question students guide them toward focusing on designing their plan?

Ms. Ramirez's 5th Grade Vignette: Guided FieldDesign Project

Xavier's group decided on trying to secure recycled materials to create bird houses. As they are filling in their Project Plan sheets, she overhears their discussions about some of the potential barriers.

"One of the things we wrote down to think about is whether all recycled materials are safe for birds. How will we know which ones to use?" asked Delilah.

Jacob replies, "We can just look it up in books or online. We are probably not the first people who wanted to recycle to help birds in the whole world. Somebody has to have information."

Ms. Ramirez asks, "What do you suppose the materials are that may be better or worse for our local birds?"

"I think glass would not be good for a lot of reasons. It's heavy to hang, it's hard to attach, and it may get hot inside like a car's windows," one replies. Another adds, "And it's breakable, could be hard to get unbroken glass that's usable." The team agrees.

Jacob suggests cardboard. "Cardboard is light, we can bend it and tape or glue it to make whatever sizes we need for each bird."

"What about rain?" asks Xavier, "If it rains it might get soft and soggy."

As Ms. Ramirez predicts they will have difficulty hypothesizing about materials, she suggests they use the Project Plan to guide their thinking. "You are considering very important things, let's make sure you record them for use later if needed."

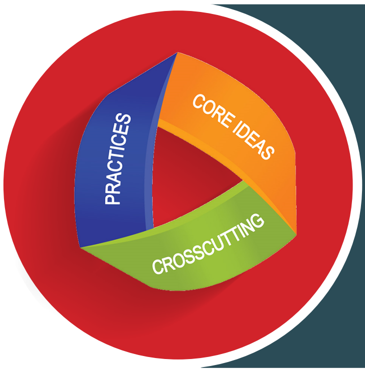
The group completes the Project Plan and they begin the procedures and constraints.

"I've heard you share some constraints, let's list those, then we can think through how to make the best birdhouse with safe materials," shares Ms. Ramirez.

In the end, each group member agrees to research a material and determine its environmental impact. Xavier offers to check with his grandma, a local Audubon member, about specific local species and the materials they prefer. The team will reconvene soon to share their findings and begin implementing their solution.

4 STEP

IMPLEMENT AND TEST THE SOLUTION



NGSS INFORMATION: SCIENCE AND ENGINEERING PRACTICES

- Asking Questions (Science) and Designing Solutions (Engineering)
- Developing and Using Models
- Analyzing and Interpreting Data
- Engaging in Argument from Evidence
- Obtaining, Evaluating, and Communicating Information

As the students begin to implement the steps of the plan, they should record progress in their science notebooks. Each day the class works on their projects, they should report out accomplishments, new constraints and next steps. Having all students understand the group expectations for their involvement is important. This will also help you as facilitator link together supporting plans. For example, if one group decided to contact the ornithologist about species habitat needs and another group contacts them for feedback on using recycled materials, you could facilitate both groups interviewing the expert at the same time.

How will students record successes and any changes that happen during the project? Changes are inevitable, designing an organization tool for noting progress and shifts, in their science notebooks, will be important when students are preparing their presentations. A FieldDesign Notes organizer can be used by students to track their progress and prepare to share next steps. Facilitators can alter the FieldDesign Notes organizer to accurately depict the steps in their students' projects as needed, however it should always include reflection questions (Reasoning) to allow students to focus on the value of their project. In early grades this work could be short conferences where teams answer questions the facilitator asks. Reflecting on failures and successes in the design process is an important part of the learning.

FieldDesign Notes become a chronological record of activities, adjustments, and changes made. They will ultimately be used to summarize challenges and impacts of the choices made, evaluate the success of the project, and guide presentations describing how effective solutions were and whether optimization may be needed to better meet the criteria and constraints of the problem.

Engineers use investigation both to gain data essential for specifying design criteria or parameters and to test their designs. Like scientists, engineers must identify relevant variables, decide how they will be measured, and collect data for analysis. Their investigations help them to identify how effective, efficient, and durable their designs may be under a range of conditions. (from A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas, page 50)

FieldDesign Notes

As you carry out your plan, use these prompts to share the steps you have taken.

Date:

Contributors (list individuals you worked with):

Project location:

Steps:

Reflection:

- How did your actions have an impact on the project's success?
- Did your action impact ecosystem health? If so, how?
- Is the project going according to plan?

Do you need to change your plan? If so, how? (Be sure to record changes on your Project Plan if you make them)

Next Steps:

Mr. Canon has planned to interview students and collect data on certain practices he is focusing on developing with his students, one of which is developing procedures. While Mr. Canon begins releasing decisions and responsibility to his students during this project, he guides their decision making to include evaluating how successful they are when implementing their planned solutions. How has his facilitating the discussion helped students consider self-evaluation?

Mr. Canon's 2nd Grade Vignette: Facilitator-Selected FieldDesign Project

Mr. Canon has propped some seed packets on the marker tray of the board as he sits near a prepared chart.

"As we began working on designing our garden, we identified some challenges we need to work through. One was how to water our garden. How do you think we have done when making plans for our challenges?" Students share that they feel happy that they are planning to solve challenges together, and they have ownership deciding what they can try.

"This week we are going to begin constructing our garden, and also begin tracking our progress on creating our garden by recording what we have to do on posters like this." Mr. Canon points to a poster version of the Field Notes that can be recorded individually in this step. "I've added the date already, because scientists always include dates in their notes so that when they review what happened a while ago, they know how long ago it was."

The class discusses how to fill in the "Who" portion, they decide to record "Mr. Canon's Class." They describe where, exactly, their garden plot is at the school and one student asks if they can include a map to clarify what they have written. Mr. Canon asks the student to guide him on how to draw the map and does so next to the section titled "Specific Location", along with the narrative description they discussed.

"Now we are going to plan the Activity portion of our project. What did we decide needed to happen first to begin creating our garden? I already have the seeds my friend is giving us to use, but before we put them out in our garden, we have a few things we need to take care of. Alexi, what do you remember about our garden preparation talks? What do you think we need to do first?"

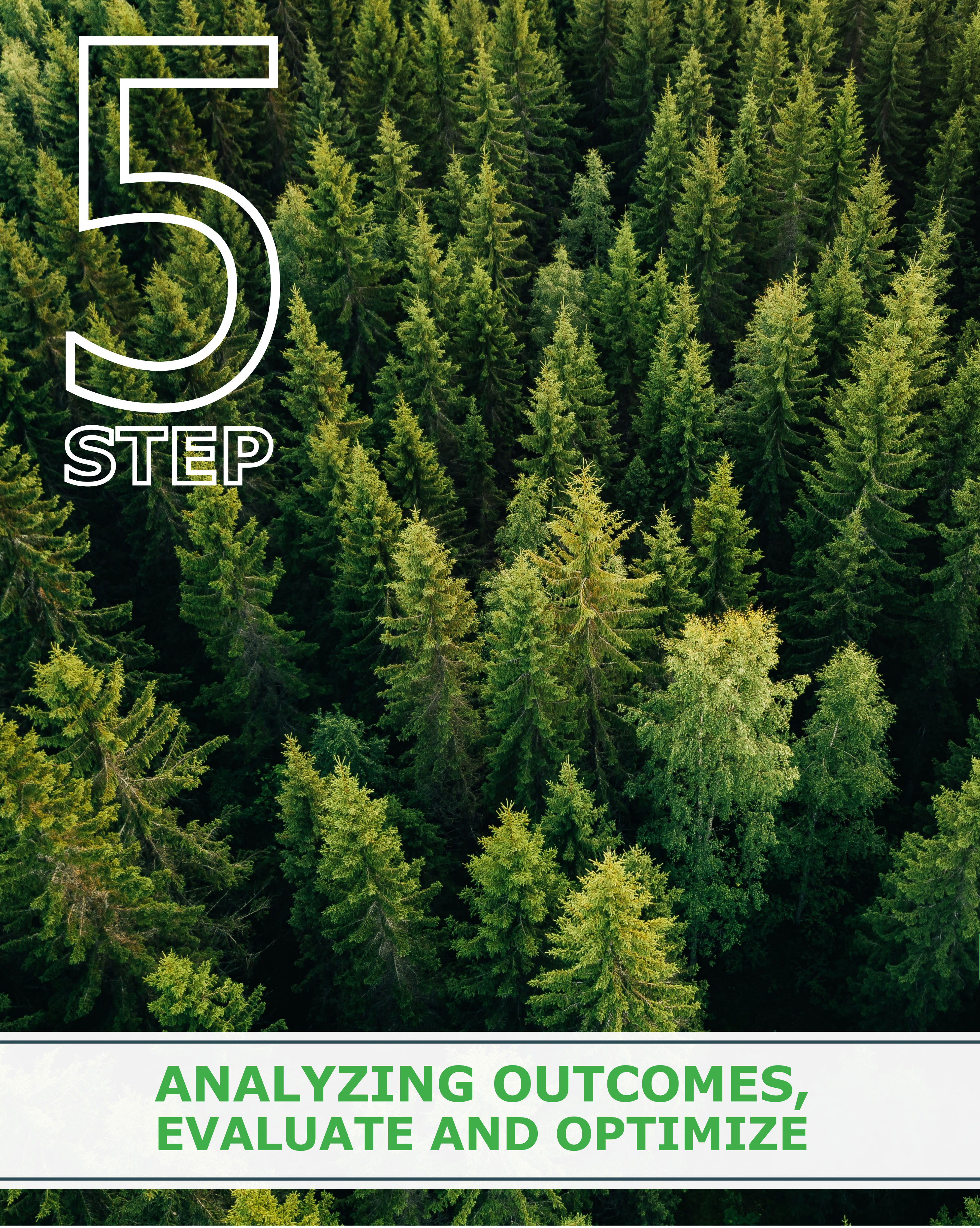
Alexi grins as he remembers, and shares, "We need to prepare our soil."

"That's right, Alexi. Now who can tell me why that is important?" Mr. Canon writes Prepare the Soil next to "Activity" and begins recording responses to his "Why" question under "Reasoning".

Once sharing slows a bit, he asks a new question. "What exactly are the steps we should follow to prepare our soil? Let's create a list of what we need to do, and then we can go back and number them to make our plan really clear." Mr. Canon knows that his students may forget a step midway, and rather than rewriting the entire process he knows that numbering will work to order their steps once they are finished brainstorming.

"When we write a process, it's almost like a recipe. If I make pancakes for breakfast, I must add all the ingredients to the bowl, mix them up, then cook them. If I forget to mix them, they don't turn out correctly. Or, if I forget the egg, but then begin cooking the mix and then add the egg on top at the end, it doesn't turn out correctly either. So, let's be really careful when we number our steps in our Process so that we can be sure we have the proper order to make the best prepared soil in our garden and our seeds will have a better chance of growing well."

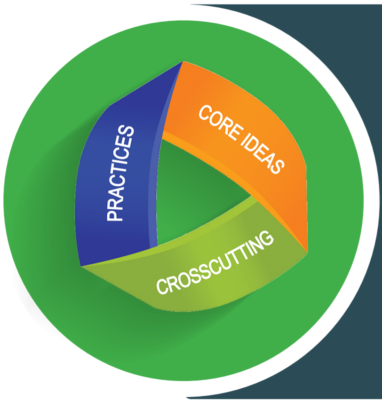
The class lists turning the soil once they've added fertilizer, getting fertilizer, getting tools, watering, removing rocks, etc. Mr. Canon writes them all on the white board next to the chart. Then they number each one according to what order makes sense. Mr. Canon finally writes the process on the chart in the order students settled on. They will follow their steps, and then reflect on how it went on their chart, making changes as necessary as a class.



5 STEP

ANALYZING OUTCOMES, EVALUATE AND OPTIMIZE

STEP 5



NGSS INFORMATION: SCIENCE AND ENGINEERING PRACTICES

- Asking Questions (Science) and Designing Solutions (Engineering)
- Developing and Using Models
- Using Mathematics and Computational Thinking
- Analyzing and Interpreting Data
- Engaging in Argument from Evidence
- Obtaining, Evaluating, and Communicating Information

Engineers analyze data collected in the tests of their designs and investigations; this allows them to compare different solutions and determine how well each one meets specific design criteria—that is, which design best solves the problem within the given constraints. Like scientists, engineers require a range of tools to identify the major patterns and interpret the results. (from A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas, page 51)

During step 5, students analyze and evaluate the outcomes of the project to prepare for a presentation. They will make recommendations on how to optimize the results they attained. To do this, students must consider the criteria for success, the positive and negative environmental impacts (both intended and unintended), and any data collected. This step reinforces the need for meaningful math and data in order to analyze situations and make suggestions based on evidence.

Step 5 revolves around reflective analysis and evaluation of the projects' successes and challenges and the planning for any adjustments needed to optimize the results. During steps 3-5 students may need to return to step 2 (research), based on data, questions or results, this potentially can lead to the need to pursue an entirely new solution. Sometimes this is disheartening for students who have invested a lot of time and effort. The facilitator's role is to emphasize that learning from mistakes and failures is an important part of the design process and leads to more sustainable solutions.

TEACHER TIP

A written summary, or report, is one way to check individual understanding and reflection, and there are many other ways to engage students in reflecting on their findings. Final presentations are in Step 6, so finding an active way to process reflections could help students synthesize. Some ideas include:

- Group discussions
- Organizing reflections digitally
- Creating an act/show about adjustments made and lessons learned
- Using sketching, models, or mind maps to capture ideas
- Voice recordings to talk through Project Summary, Analysis, and Evaluation Questions

FieldDesign Project Analysis

Using the statements and questions below to analyze the success of your project and make suggestions on improvements that might make the project more successful. (refer to your FieldDesign Notes if needed):

Date:

Team Members:

Briefly describe the problem you worked to solve and how it impacts the larger ecosystem (human and non-human):

Explain why this problem is important to your community:

List the stakeholders you worked with and identify their contributions:

Summarize the project steps, including any unexpected adjustments you had to make or challenges you had to address:

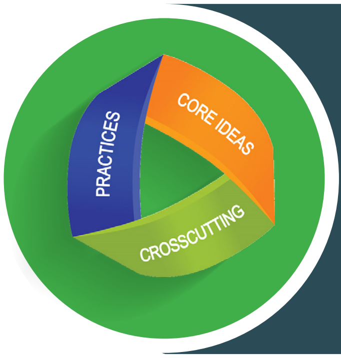
Describe how your knowledge, perspectives, or opinions about the problem changed during the project? Why?

The last question on the Project Analysis sheet is important. No matter the degree of success that was achieved in solving the problem, optimization can always occur, whether by designing revisions to the plan, decreasing project cost, adjusting how time is used, or through other improvements.

During step 5 students may find their solution was completely ineffective and they are out of time to complete the project with an optimized solution. It may be necessary to move to step 6, to present the newfound data so that others can use it as research when they work to plan a different solution to the problem. If students have time to continue to pursue the problem with an optimized solution, they would repeat steps 2-5 Stakeholder Research, Solution Analysis, Solution Comparison, Project Plan, FieldDesign Notes, and the overall evaluation once students return to step 5.

6 STEP

PRESENT FINAL SOLUTION
USING SCIENTIFIC REASONING



NGSS INFORMATION: SCIENCE AND ENGINEERING PRACTICES

- Asking Questions (Science) and Designing Solutions (Engineering)
- Developing and Using Models
- Analyzing and Interpreting Data
- Engaging in Argument from Evidence
- Obtaining, Evaluating, and Communicating Information

One of the goals of FieldDesign is to give students active and meaningful opportunities to participate in their community. Throughout the project as students share information with their teammates and the community members working with them on the project, they are practicing using new vocabulary and new information. The more opportunities they have to communicate about their projects as they are engaged in it, the more likely they will gain comfort in presenting. Even young learners should be offered opportunities to present to community decision makers so by the time they are in middle or high school they are proficient speakers and effect change in their communities; student voice becomes a valued part of the community.

Using the FieldDesign Project Presentation organizer, students present to peers and stakeholders their reasoning, plan, and impact of their project. Students should focus on the data they collected during the project as evidence of the project's success, or the need for optimization. Communicating results using scientific reasoning is a practice that "real scientists" use. Students practice their skills of utilizing and citing evidence to support scientific reasoning in their presentation. Citing evidence is an important practice in CCSS Mathematics and student competencies ELA, allowing for strong integrated learning.

Presentation types will vary depending on the audience, grade level, and need to assess student learning. Students can communicate the information as individuals or groups. Some ways for students to communicate project results include:

- Oral presentations
- Poster presentations
- Project reports
- Brochures
- Narrative writing assignments
- Video productions
- Blogs or social media posts
- Artistic performance (song, commercial, skit) or graphic art (sculpture, draw, paint)

Encourage students to communicate their findings beyond the classroom. If possible, have your class present to a wider audience. Possible audiences include the student body or School Board, relevant community organizations and stakeholders, or attendees of a regional student summit or science fair.

Each type of presentation will require some expectation guidelines from the facilitator. In general, here are some guidelines that students can use to plan their presentations, however facilitators should revise the Project Presentation Organizer to meet local opportunities, audiences, and presentation types.

FieldDesign Project Presentation Organizer

You will use the notes from your FieldDesign Project Analysis to plan the information you share during your project presentation. Use this organizer to plan how to communicate all you have learned in this process, and how successful the project was or recommendations for future work.

What was the project?
(explain what you were trying to accomplish)

Why should others care about your project?

Who contributed? (including teammates and stakeholders)

When and where did your project take place?

What are your results?

Did the solution work? How did you determine whether it was successful? What method did you use to determine success based on scientific reasoning and the criteria for success?

What adjustments would optimize the results of this project if it was replicated somewhere else?

How did your thinking change because of working on this project? What have you learned?

What recommendations do you have for your school or community based on the results of your project?

After planning for the above questions, brainstorm three questions your audience may have and what your answer would be. This will prepare you for the question and answer period after your presentation.

Question	Answer
1.	
2.	
3.	

Mr. Canon's 2nd Grade Vignette: Facilitator-Selected FieldDesign Project

The second-grade class has completed planting their garden and has implemented practices for caring for their plants according to their adjusted plans.

Mr. Canon uses the Project Analysis questions to guide students in a group discussion, which will inform how they will eventually share about the project with others in the community. He records the all the answers students share, and then assigns each question or reflection to a pair of students who will be the experts on that question. Students will use all the answers shared in their discussion to craft how they will present and are excited to be an expert in an area of their presentation.

Ms. Ramirez's 5th Grade Vignette: Guided FieldDesign Project

Ms. Ramirez projected a copy of the FieldDesign Project Presentation questions for the students. She has posted a menu of ways students can communicate their findings on the board (digital presentation, newspaper or magazine article, poster project, and creative writing, etc.) Ms. Ramirez explains that she chose the communication types to overlap some of the students' English Language Arts requirements and says that she has a checklist for each choice that explains what must be included to meet the class expectations. She explains that this is part of the process of final presentations, not the final presentation, and then shares the two-day deadline. Students begin excitedly choosing which format they prefer for their product, and then begin answering the questions as a team.

After two days, Ms. Ramirez meets with teams to take notes on how they analyzed their success. Their conversations and her questions will set up teams to communicate their findings. She collects project artifacts for her ELA grading as well.

Mr. Canon's 2nd Grade Vignette: Facilitator-selected FieldDesign Project

Mr. Canon has proposed to the group that they create a news broadcast that Ms. Jacey and other interested adults could watch in order to learn what they have accomplished. He explains that they will still be the expert in the area they reflected on. The students are excited to create a news story with their successes.

"We have worked so hard together to create our garden, and make sure that our special seed survived well enough to thrive. Part of being scientists is learning from our experiences, and we do that through thinking about our notes. As we create our newscast, let's use some questions to guide us so that we stay focused and informative for our viewers."

Mr. Canon uses the questions from the Project Presentation Organizer to outline how they will stage the interviews, and the group decides where each pair of experts fit into the organizer's flow. Students practice how they will respond, and through practice the class ends up processing even more deeply the entire project and how to communicate all that they learned.

Ms. Ramirez's 5th Grade Vignette: Guided FieldDesign Project

Given that Ms. Ramirez's class began this project because of changes to the habitat near their school yard, and the reactions she witnessed around how the construction company had followed the law about tree removal, she contacted her city council member to ask if students could present their project and results and they were accepted. Her class was excited that children were given a date and time to show what they were able to accomplish toward solving a local problem.

"We have a big opportunity with this presentation," Ms. Ramirez shared. "When we first began investigating the bird population decline, some of you shared that children had no power for change. We may have opened a door for that, let's be sure we share all our successes as well as what problem we were trying to solve in the beginning."

The group discussed whether having one spokesperson would be most effective, or whether having multiple speakers would be more interesting to the council. For those who didn't want to speak, the group decided that they would create informational brochures with highlights of all the team projects to leave with council members. Others created posters illustrating the projects so that there would be visuals to accompany those presenting on each project. Every student had a contribution to make.

As visuals teams began their work, presenters teams processed the format they would use to share about each project. They decided they wanted to start by sharing the problem that spurred all the work to grab the council's attention. Ms. Ramirez shared the Project Presentation Organizer to frame their presentations, and the group decided to transition at "Who" for each oral presenter to jump in for their team's turn to share their project and findings.

Although on the night of the City Council Meeting there was no commitment to changing the laws on removal of trees, Ms. Ramirez could see impressed expressions on the council members' faces, and proud expressions on her student citizen scientists. Whether they spoke or supported with visuals, her class had worked as a team to solve a problem that they valued and were able to communicate what they learned as well.

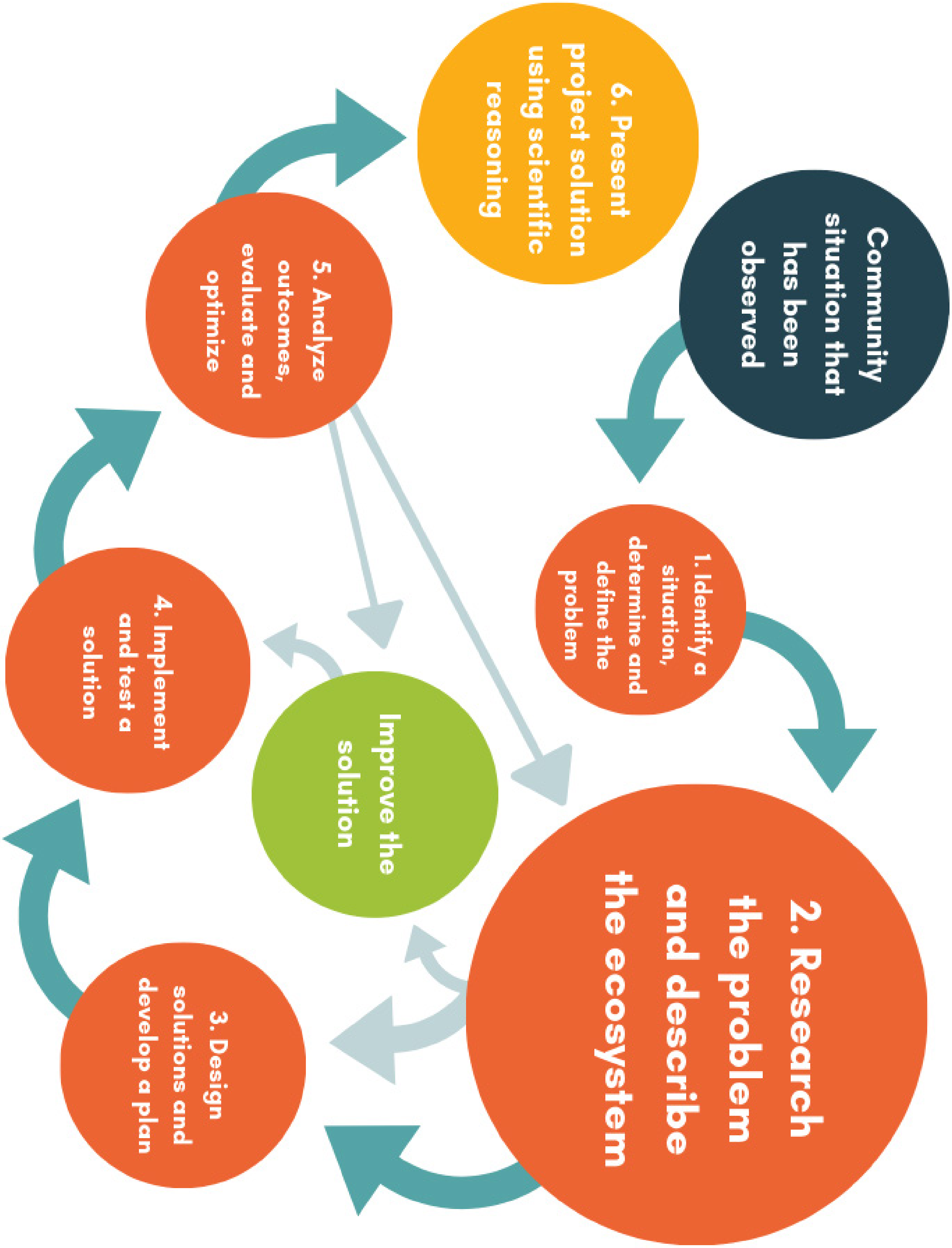
No matter whether facilitator-selected or guided FieldDesign processes are followed, students who engage in this learning make fluid decisions in order to tackle a real life, community impacted environmental challenge. They bump up against barriers and adjust to overcome them as adults do in their work. They work through potential frustrations and learn that they have capacity to learn from unexpected mistakes. Their learning moves through a cycle that matches "real life" learning.

As facilitators, our role is to guide students through this process as well as monitor how we ourselves adjust our expectations of the learning steps students move through, while keeping track of progress and scheduling into timelines available. It sounds hard! But when you consider the payoff for developing students who have built confidence in their capacity for reflection and flexibility, have applied their thinking at an application level through nearly an entire unit of study and project, and who have become more connected advocates for the environment in which they live, isn't it worth a little uncertainty for the first time?

APPENDIX

Appendix

1. The FieldDesign Process
2. Guidelines for Setting up a FieldSTEM Notebook
3. FieldSTEM Notebook Strategies
4. FieldDesign Student Pages
    - a. O.W.L chart
    - b. Researching the Problem
    - c. Stakeholder Research
    - d. Solution Analysis
    - e. Solution Comparison Table
    - f. Project Plan
    - g. FieldDesign Notes
    - h. FieldDesign Project Analysis
    - i. FieldDesign Project Presentation Organizer


Community situation that has been observed
1. Identify a situation, determine and define the problem
2. Research the problem and describe the ecosystem
3. Design solutions and develop a plan
4. Implement and test a solution
5. Analyze outcomes, evaluate and optimize
6. Present project solution using scientific reasoning
Improve the solution

Guidelines for Setting up a FieldSTEM Notebook

Materials needed every time you teach FieldSTEM in the classroom:

- ☐ Science Notebook (have a place to keep notebooks that stay in the classroom)
- ☐ Colored pencils/crayons (color helps the brain learn and remember)
- ☐ Glue/scotch and packing tape (to secure important data, foldables, data sheets, graphs, etc. that are essential to the learning experience)
- ☐ Highlighter (for highlighting important ideas)
- ☐ Post it notes – for collaborative conversations

Getting Set up:

- ☐ At the start of the year, discuss how FieldSTEM will be incorporated into their learning and encourage students to decorate the cover over the course of the study. Have them select one image to add during week one (covering with packing tape will help keep it down) Number the pages in the bottom right hand corner (encourage students to write really small)
- ☐ Page 1- Ensure students write their names on both the cover and on the Title page
- ☐ Page 2- Collaborative Community contract, glued in after students sign the contract
- ☐ Pages 3-6- Table of Contents (with support and modeling by the teacher, students list the date, title, and pages of each experience)
- ☐ Select 4-6 pages at the end for the Glossary.
- ☐ For stronger notebooks: Open notebook to the center stapled page. Slide in a rubber band (size 31/2 x 1/16 works well), binding the pages to the front cover. Close notebook. Reinforce the spine of notebook with packaging or duct tape.

Key Final Thoughts:

- ☐ Make the FieldSTEM Notebook design work for you and how you structure your classroom
- ☐ Model FieldSTEM Notebook use for your students.
- ☐ To the extent possible have students create their own forms, tables, graphs etc. and differentiate with pre-made sheets as necessary.

FieldSTEM Notebook Strategies

Using modeled scaffolds (graphic organizers, writing frames, etc.) where there is a gradual release of responsibility toward creating these independently, FieldSTEM notebooks promote the development of English language arts and math skills by utilizing them in service of engaging, locally important problems, issues, questions and opportunities.

While FieldDesign provides templates for organizing student work, educators must resist the temptation to provide pre-made scaffolds, worksheets, data chart, etc. for students and instead encourage students to embrace their need to learn and grow in their skills. Students will learn to develop effective tables for data collection only if they are allowed to struggle with the number of rows and columns and how to label them. Ultimately, opportunities like these provide students with the skills to think critically, work and communicate in collaborative ways and make informed decisions on behalf of their community.

There are many strategies to engage student in utilizing their FieldSTEM notebook. A few are listed here. PEI readily admits these strategies have been used in classrooms for decades and called many things, we offer them here as examples of ways to utilize FieldSTEM notebooks.

Notebook Strategy: Developing Student Thinking

At PEI we promote students' sense of wonder. The following FieldSTEM notebook strategy will encourage this sense of wonder while simultaneously developing student thinking.

Left Side/Right Side
In a FieldSTEM notebook, you would model:

LEFT SIDE
Output

Student generated entries on this side demonstrate understanding of the information on the right side, focuses attention, guides student learning of content and concepts, and are a good resource for student created investigations and focus questions.

Every left side page gets used.

Entries can include:

-brainstorming	-self reflection
-photos	-illustrations
-models	-diagrams
-poems	-concept maps
-songs	-design process ideas
-questions	-wonderings
-mapping	-flow charts

RIGHT SIDE
Input

Information from other sources including teachers, texts, observations from activities.

Entries on this side are connected to learning goals, capture content, ideas and evidence for future reference, provide assessment and feedback opportunities and drive instruction.

Entries can include:
-focus question
-mapping
-field investigation notes/data
-vocabulary
-speaker, text or video notes
-lab activities
-entry types; data tables,
-date, time, location, weather
-diagrams, comparisons

Notebook Strategy: Collaborative Communication

Evidence of a student's conceptual understanding can be communicated by assessing the student's thinking, skills and understanding of content in their FieldSTEM notebook. Look for evidence of these elements and others in what they've captured in their entries. Utilizing the Next Generation Science Standards evidence statement for any given
performance expectation may be useful. Engage in collaborative conversation around the entries: teachers and other students who have been coached on constructive feedback can provide input on a "post it note" or orally. Strengths should point to specific information and examples and how they meet the criteria/evidence statements. Weaknesses should be addressed in the form of a question that a scientist or an engineer would as, "Do you think another engineer would need more information to understand?". An effective collaborator will eliminate vague feedback like "good job" and use questioning strategies. A sample of FieldSTEM notebook entry questions that help a collaborator understand and move another person's thinking forward are:

- What did you observe that makes you think that?
- What evidence do you have to support your thinking?
- Have you recorded your evidence accurately?
- Do your results support your prediction? If not, how has your thinking changed?
- Are there people in the community that would agree with this thinking?
- What do you think happened during your project that led to inconsistent or inconclusive data?
- Have you reread your entry to see if any changes are needed to make it more clear or accurate?
- What are your next steps?

Notebook Strategy:
Sentence Frames for Differentiated Instruction

To help students become independent writers it is important to model how to organize the thinking and evidence they capture in their FieldSTEM notebooks. With consistent modeling and support and then a gradual release of responsibility with writing frames, you are providing a tool for emerging writers that allows students to use ELA skills successfully to access STEM in the world around them and share their thinking with others. These frames can be used for sharing evidence orally as well. Simply post the phrases in a pocket chart or on a bulletin board then model and practice their use.

Elementary FieldSTEM Notebook Writing Frames

Observations:	I observed_____.
Compare:	A ___ has ____ and ___, a ____has ___and____ and both have ___.
Contrasts:	_____, but _____.
	At first, _____, but now_____.
Sequence of Time:	First,_____. Next,_____. Then,_____. Finally,_____.
Predicting:	I predict that _____will _____because_____.
Cause and Effect:	_____because_____.
	If_____, then_____. So,_____.
Reasoning:	I think_____, because_____ .
	_____because _____.
	At first, I thought___, because___. Now I think____, because____.
Conclusions:	For the following reasons_______, and______, I think _____.
Claims and Evidence:	I think ____ because ___. If you do ____ then _____ because ___.

Notebook Strategy:
Activating Prior Knowledge and Preconceptions

Goal: To help students identify what they have already experienced or observed about the topic and to make connections.

Capture student thinking:

- On a O.W.L. chart or another graphic organizer
- Individually, in groups, or as a whole class
- Sparked by a different content area connection (i.e. poetry or art on the topic)

Possible prompts:

- What does (project topic or term) make you think about?
- Have you _________ before?
- What do you think about when you look at …?

O.W.L.: Human Impacts on Our School Grounds		
Observations	**Wonderings**	**Learnings**

Researching the Problem

1. **In one sentence, describe *the problem* you're planning to solve:**

2. **Why is this problem important? What will happen if no changes occur?**

3. **What I already know that may help:**

4. **What I need to know before starting:**

5. **Where I might find the information (books, websites, experts, etc.):**

Researching the Problem (Continued)

My notes (cite your sources):

1. **The problem (complete sentence):**

2. **Criteria (goals):**

3. **Constraints (limitations):**

4. **What I know now that may help:**

Stakeholder Research

Stakeholder name (individual, organization, business, agency):

Stakeholder website:

Contact name:

Contact phone number/email:

How is this stakeholder connected to the problem?

Is the stakeholder aware of the problem? If so, what are their opinions about it?

If the stakeholder owns the land where the project would take place:

- **How do they currently use the land?**
- **Does that use of the land impact the problem? If so, how?**
- **Are they trying to be environmentally friendly? Explain.**
- **Are there laws that affect the way the stakeholder can use the land?**
- **Are there any culturally or familial connections that ties the stakeholder to the land?**

How could the problem affect the stakeholder now and in the future?

How could the stakeholder contribute to the problem?

How could they be a part of the solution?

Would the stakeholder like to play a role in this project? If yes, what role?

Would the stakeholder be interested, financially, in finding a solution?

Solution Analysis

You are ready to brainstorm possible solutions to the problem! Others may have tried to solve the same problem in the past. Research what solutions have been tried. This information may come from your stakeholder research or from new information you have gathered.

You also may have some of your own ideas of possible solutions. Each possible solution will have its own set of positive impacts and negative consequences. To decide the best possible solution to the problem you chose, follow this process with each solution you learned was already tried and those you have developed.

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1. **Create a list of possible solutions. Write down all possible solutions you learned about during your research as well as your own ideas:**

2. **Narrow your list down. Cross out any ideas that don't seem realistic or do not interest you. (**Keep in mind that just because some projects will require access to expert opinions or money, it doesn't mean the solution is unrealistic. Groups and businesses are often willing to donate materials, time, and resources to help students with projects)

3. **Choose your top 3 solutions. You will start by analyzing only these 3 in order to decide which one you plan to complete.**

4. **Compare solutions using the Solution Comparison Table.**

5. **Choose the best solution for your project based on the Solution Comparison Table and share your choice with your teacher to get approval for your project.**

SOLUTION COMPARISON TABLE

Possible Solution Summary	**Criteria for success and positive impacts**	**Potential negative consequences**	**Stakeholder thoughts**	**Constraints that may make this difficult**	**Is the plan reasonable?**
Who was/will be involved in the project? What did/will they try? How did/will they go about their solution? When was/will this be? Where was/will this be?	What positive impacts on the environment could come from this solution?	What results of this solution could be harmful?	What might stakeholders like or dislike about this solution?	Consider time, resources, liability, etc.	Rank how likely it could be completed: 1 = low 2 = Medium 3 = High 4 = Certain

Name: ______________________________ Date: _____________

Project Plan

Use details from the Solution Analysis (and any additional information gathered through research) to create a project plan.

1. Purpose: What is the problem you are trying to solve?

2. Ecosystem Impacts: Where is the problem? Be as specific as you can. Describe how this project connects to the surrounding ecosystem. How could it have positive and negative impacts?

3. Summary: In a few sentences, summarize your project and include how it will solve the problem and impact the ecosystem.

4. Table of required resources:

Resources needed:	**Source:**	**Cost or donation value:**
Total cost of project:		

Project Plan (continued)

5. Procedure and timeline for your project. Include dates for each step if possible and who in your team is responsible for the step. Keep in mind any further research and/or investigations you will need to complete. Include time to evaluate and possibly adjust your project plan during the process.

6. Constraints: What might cause problems or interfere with your project? How will you prepare for those limitations or challenges?

7. Evaluation: How will you measure your project's success and prove it turned out like you want and it to? Make a list of criteria that you will use to evaluate the outcomes, including measurements.

8. Project contributors: List all contributors for this project, including project teammates, experts, and stakeholders.

Name	Title/Job	Organization	Email	Phone Number

9. Project Reflection: Reflect on your project and answer the following questions.

- What is your individual role in this project?

- What excites you about the project?

- What worries you?

Notes:

FieldDesign Notes

As you carry out your plan, use these prompts to share the steps you have taken.

Date:

Contributors (list individuals you worked with):

Project location:

Steps:

Reflection:

- **How did your actions have an impact on the project's success?**

- **Did your action impact ecosystem health? If so, how?**

- **Is the project going according to plan?**

Do you need to change your plan? If so, how? (Be sure to record changes on your Project Plan if you make them)

Next Steps:

FieldDesign Project Analysis

Using the statements and questions below to analyze the success of your project and make suggestions on improvements that might make the project more successful. (refer to your FieldDesign Notes if needed):

Date:

Team Members:

Briefly describe the problem you worked to solve and how it impacts the larger ecosystem (human and non-human):

Explain why this problem is important to your community:

List the stakeholders you worked with and identify their contributions:

Summarize the project steps, including any unexpected adjustments you had to make or challenges you had to address:

Describe how your knowledge, perspectives, or opinions about the problem changed during the project? Why?

What suggestions do you have to optimize the solution?

FieldDesign Project Presentation Organizer (continued)

After planning for the above questions, brainstorm three questions your audience may have and what your answer would be. This will prepare you for the question and answer period after your presentation.

Question	Answer

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PACIFIC
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