EngrTEAMS

EngrTEAMS: Engineering to Transform the Education of Analysis, Measurement, and Science in a Team-Based Targeted Mathematics-Science Partnership

Loon Nesting Platforms

Grades 6-8

University of Minnesota
STEM Education Center
NSF
INSPIRE Research Institute for Pre-College Engineering
Purdue University

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About EngrTEAMS

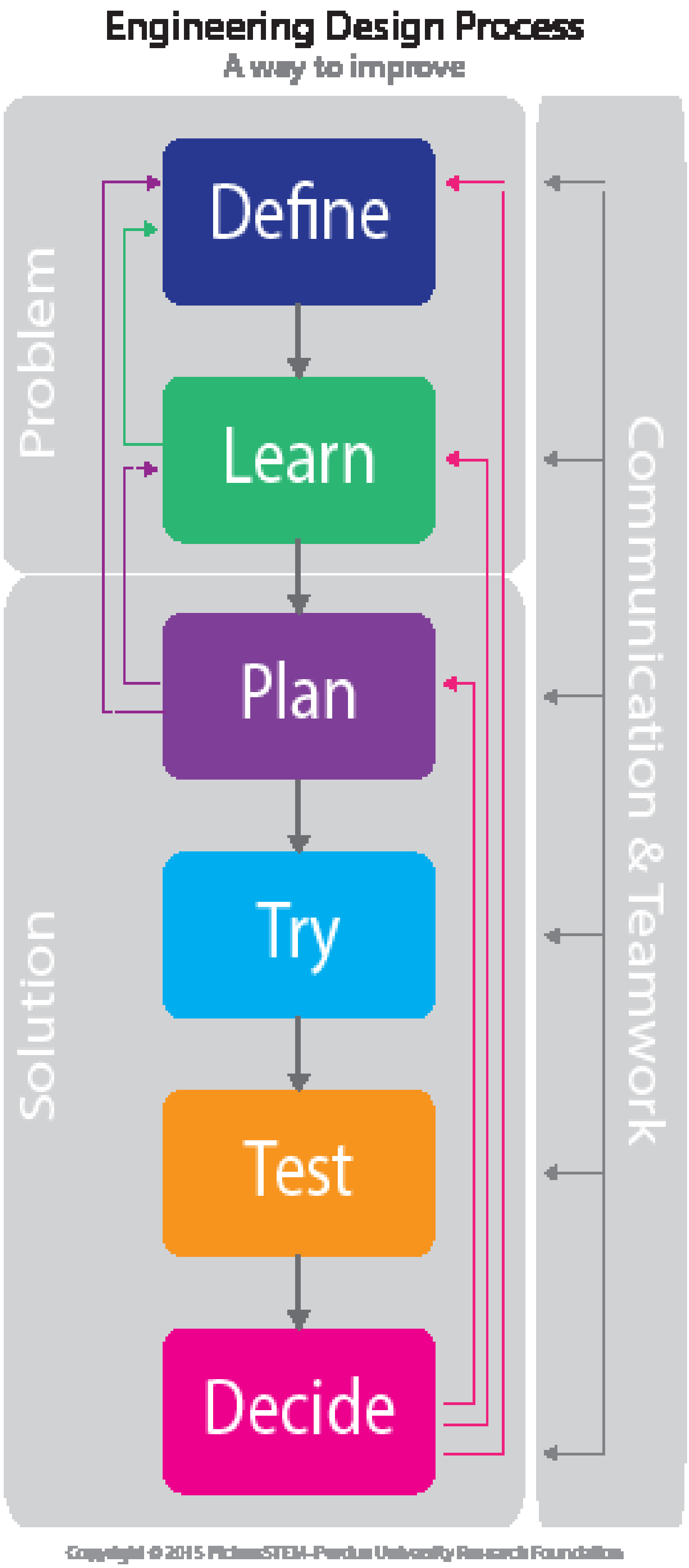
Purpose

The project is designed to help 200 teachers develop engineering design-based curricular units for each of the major science topic areas within the Minnesota State Academic Science Standards, as well as data analysis and measurement standards for grades 4-8.

With a focus on vertical alignment and transition from upper elementary to middle-level, this project will impact at least 15,000 students over the life of the grant.

To learn more about the project and find additional curricular units go to www.engrteams.org.

Overview



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DEFINE THE PROBLEM

- Who is the client? What does the client need? Why does she or he need it? Who are the end-users?
- Why is the problem important to solve? What are the criteria (requirements) of the solution? What are the constraints (limits)?
- Problem Scoping: WHO needs WHAT because WHY

LEARN ABOUT THE PROBLEM

- What kind of background knowledge is needed to solve the problem? What science/mathematics knowledge will be needed? What materials will be needed?
- What has already been done to solve the problem? What products fill a similar need?
- How should we measure improvement?

PLAN A SOLUTION

- Continue to specify the criteria and constraints
- Idea generation
- Develop multiple possible solution paths
- Consider trade-offs and relative constraints
- Choose a solution to try
- Develop plans (blueprints, schematics, cost sheets, storyboards, notebook pages)

TRY A SOLUTION

- Put the plan into action
- Consider risk and how to optimize work
- Use criteria, constraints, and trade-offs from problem/plan to build a prototype (a testable representation of a solution), model, or product

TEST A SOLUTION

- Consider testable questions or hypotheses
- Develop experiments or rubrics to know if the solution is meeting the stated criteria, constraints, and needs
- Collect and analyze data

DECIDE WHETHER SOLUTION IS GOOD ENOUGH

- Are users able to use the design to help with the problem?
- Does your design meet the criteria and stay within the constraints?
- How could your design be improved based on your test results and feedback from client/user?
- Iterative nature of design: Consider always which step should be next!

COMMUNICATION & TEAMWORK

- Good oral and written communication and teamwork are needed throughout the entire design process.
- The client should be able to create/follow the solution without ever speaking to you. Include claims and use evidence to support what you believe is true about your solution so that the client knows why they should use it.

Overview

Grade Levels: 6-8

Approximate Time Needed to Complete Unit: Thirteen 54-minute class periods

Unit Summary

Students will be learning about ecology and ecosystems through the construction of loon nesting platforms. First, they will explore human impact on ecosystems and the roles of organisms in ecosystems. Next, they will analyze qualitative and quantitative data to find a good location for their platform based on habitat characteristics and dietary needs of the common loon. After additionally incorporating knowledge of food chains and food webs, students will be able to make an educated decision as to which lake would be a suitable place for their nesting platform. Students will also have the opportunity to improve the design of their nesting platform and to summarize their learning throughout the unit.

Science Connections	Technology & Engineering Connections	Mathematics Connections
Energy flow through a food web/ food chain; human impact on the environment; components of lake ecosystems	Completion of a cycle of the engineering design process; using tools and technologies to analyze data and test and evaluate prototypes	Data analysis and measurement; graphing; percentages; area; proportional reasoning

Unit Standards

Next Generation Science Standards

- MS-LS2-3. Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.
- MS-LS2-4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.
- MS-LS2-5. Evaluate competing design solutions for maintaining biodiversity and ecosystem services.
- MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
- MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
- MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

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- MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
- MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Common Core State Standards - Mathematics

- 7. G.B.4. Know the formulas for the area and circumference of a circle and use them to solve problems; give an informal derivation of the relationship between the circumference and area of a circle.
- 6.RP.A.3. Use ratio and rate reasoning to solve real-world and mathematical problems, e.g., by reasoning about tables of equivalent ratios, tape diagrams, double number line diagrams, or equations.
- 7.RP.A.2. Recognize and represent proportional relationships between quantities.
- 7.RP.A.2.A. Decide whether two quantities are in a proportional relationship, e.g., by testing for equivalent ratios in a table or graphing on a coordinate plane and observing whether the graph is a straight line through the origin.
- 7.RP.A.2.B. Identify the constant of proportionality (unit rate) in tables, graphs, equations, diagrams, and verbal descriptions of proportional relationships.

Unit Assessment Summary

- Throughout this unit, each student will maintain an Engineering Notebook to document their engineering design processes. In this, students will make observations, collect data, and plan for the location of the lake and loon nest. Part of the Engineering Notebook will include answering specific questions related to that day's activities. You may choose to post the questions in your overhead/PowerPoint slides, or give the students printed versions to tape into their Notebooks. Students will also use their Notebooks as a reference – a place to maintain the information they are learning through design. Additionally, students will reflect on their work throughout the design process. This is important for modeling what real-life engineers do. **Collect the Engineering Notebooks at the end of each class.** You will use the Notebooks to assess student learning and their design process. Read the Notebooks and provide feedback to students. You are encouraged to assign points for responses in the engineering notebooks.
- The notebook pages are often set up as handouts in each lesson. If you prefer to use notebooks without having students paste copied pages in them, there is an appendix at the end of this unit that includes notebook prompts and how to have students title each entry.
- The final summative piece of this unit requires students to write a letter back to the client that reports back on their findings of which platform worked the best.

Overview

Lesson Summaries

Lesson 1: Move it or Lose it

Students will brainstorm different ways that humans have had an impact on the environment. They will learn about shoreline development and will be presented with the engineering challenge.

Lesson 2: Loon-ey Toons

Students will go on a scavenger hunt to learn basic information about common loons. After the scavenger hunt, students will learn the basic vocabulary terms *organism, population, community,* and *ecosystem.*

Lesson 3: What's for Dinner?

Students will investigate the concepts of food chains and food webs and the roles that different organisms play in them. Students will construct a food web specific to a loon's ecosystem.

Lesson 4: Loons Like Lakes

Students will learn about biotic and abiotic factors in an ecosystem. They will then choose a suitable lake for a loon platform by analyzing data from several lakes in the Minneapolis-St. Paul metro area.

Lesson 5: Nest Sweet Nest

Students will match pictures of common birds to pictures of their nests. They will calculate the area of an actual loon nest and scale it down by 25% to build their prototype.

Lesson 6: If You Build It, They Will Come

Students will build and test their prototype for buoyancy and ability to withstand waves.

Lesson 7: Your Best Nest

Students will redesign their prototype and summarize their learning from the unit in a persuasive letter to the client.

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Overview

Overview

Lesson	Time Needed	Objectives The student will be able to:
1: Move It or Lose It	Two 54-Minute class periods	**Science Lesson Objectives** • Identify different ways that humans have impacted wildlife and the environment • Categorize and rank human impacts on the environment **Engineering Lesson Objectives** • Define the problem based on the client's needs • Gather information to examine the problem (ask questions to client) • Describe the problem based on a synthesis of information • Explain why the problem is important to solve based on evidence • Describe the relevant client needs based on evidence • Identify the relevant end user • Describe the background knowledge needed to develop a solution • Describe criteria based on synthesis of given and found information • Describe constraints based on synthesis of given and found information
2: Loon-ey Tunes	One 54-minute class period	**Science Objectives** • Summarize basic characteristics of common loons based on the results of a scavenger hunt • Define key vocabulary terms, represent the relationships between them **Engineering Objectives** • Describe the needs of the end user • Describe the background knowledge needed to develop a solution
3: What's for Dinner?	Three 54-minute class periods	**Science Objectives** • Differentiate between producers, consumers, and decomposers • Create a food chain • Create a food web • Describe how energy flows through a food chain and a food web

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Overview

Materials * required materials not included in the kit	Duplication Masters
• **Per Class:** 1 - Poster paper • **Per Group:** none • **Per Student:** 15 - cm/1 g/1 mL, 1 - Paper clip, 1 –Engineering Design Process slider, 1 - Ziploc sandwich bag, 1 - Dry erase marker, 1 – Pad, Sticky Notes, 1 – Engineering notebook, 2- Different colored pens/pencils	• 1.a. What Do You Know About Human Impact? • 1.b. We Built This City! (Board Game) • 1.c. We Built This City Reflection • 1.d. Memorandum **EDUCATOR RESOURCES** • 1.e. Problem Scoping Prompts
• **Per Class:** none • **Per Group:** 1 - Poster paper, 1 – Glue stick, 1 - Scissors • **Per Student:** 1 – 8.5 x 11" sheet of paper, 1 - Engineering Notebook, 1 – Pad Sticky Notes, 1 - Paper Clip, 1 –Engineering Slider, 2- different colored Pens/Pencils	• 2.a. All About Loons! Scavenger Hunt • 2.b. Scavenger Hunt Cards **EDUCATOR RESOURCES** • 2.c. Foldable Vocabulary Tool
• **Per Class:** none • **Per Group:** 1 – Large Poster Sheet, 1 – Scissors*, 1 – Ziploc sandwich bag, 1 – Tape/Glue *, 1 – Box of Markers*, • **Per Student:** 1 – Computers** [Reserve Computer Lab], 1 – Engineering Notebook *, 1 – Paper Clip*, 1 – Engineering Slider*, 1 – Pen/Pencil*	• 3.a. Food Chain Game: Introduction • 3.b. Food Chain Fun on the Web • 3.c. Organism Reference Sheet • 3.d. Organism Cards

Overview

Lesson	Time Needed	**Objectives** The student will be able to:
4: Loons Like Lakes	Two 54-minute class periods	**Science Objectives** • Differentiate between abiotic and biotic factors in an ecosystem • Analyze a data chart containing qualitative and quantitative data to make a decision • Use spatial representations such as maps, graphs, and aerial photographs to assist them in making a decision on suitable nesting lake **Engineering Objectives** • Use evidence from problem scoping to generate multiple initial ideas for selecting a lake • Gather additional evidence (i.e., regarding applied science/ mathematics concepts) to help select a lake • Evaluate the alignment between the lake they propose and the problem • Communicate their solution using evidence-based reasoning • Justify why the lake they have selected is appropriate using mathematics/science concepts • Justify why the lake they have selected is appropriate based on the problem
5: Nest Sweet Nest	One 54-Minute class period	**Science Objective** • Match common birds and their nest • Compare different types of bird nests **Engineering Objectives** • Gather additional evidence (i.e., regarding applied science/ mathematics concepts) to help identify the needs of the loons (end user) **Mathematics Objectives** • Calculate the area of a circle and a square • Use percentages and proportionality to scale down the size of their nest platform

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Overview

Materials * required materials not included in the kit	**Duplication Masters**
• **Per Class:** none • **Per group:** none • **Per Student:** 1 – Pad Sticky Notes, 1 – Sheet of graph paper, Engineering Notebook, 1 - Paper Clip, 1 –Engineering Slider, different colored Pens/Pencils	• 4.a. Loons Like Lakes • 4.c. Lake Data Collection Table • 4.d. Data Chart from County Lakes (Never mentioned in lesson). • 4.e. Evidence-Based Reasoning Graphic: Lakes **EDUCATOR RESOURCES** • 4.b. Water Clarity/Time Data from DNR • 4.f. Evidence-Based Reasoning Graphic Poster • 4.g. Lake Photographs
• **Per Class:** none • **Per Group:** 1 – ruler • **Per Student:** 1 – Sheet of construction paper, 1 – Scissors, 1 - Calculator, 1 – Engineering notebook, 1 - Paper Clip, 1 –Engineering Slider, different colored Pens/Pencils	• 5.a. Your Best Nest Platform Design: Choosing Shape and Dimensions

Overview

Lesson	Time Needed	**Objectives** The student will be able to:
6: If You Build It, They Will Come	Two to three 54-Minute class period	**Engineering Objectives** • Use evidence from problem scoping to generate multiple initial ideas for the design of a nesting platform • Select a design solution through systematic evaluation of various solutions based on the problem • Build a prototype of their nesting platform • Test their nesting platform • Analyze test results of their nesting platform • Evaluate the alignment between their nesting platform and the problem
7: Redesign and Reporting	Two to three 54-Minute class periods	**Engineering Objectives** • Apply evidence gathered through test analysis to improve the performance of chosen solution • Gather additional information (i.e., regarding applied science/ mathematics concepts) to improve solution performance • Select an improved design solution through systematic evaluation of various solutions based on the problem and evidence gathered • Build improved prototype of their nesting platform • Test their improved nesting platform • Analyze test results of their improved nesting platform • Evaluate the alignment between their nesting platform and the problem • Describe what they have learned through testing and evaluation process • Communicate their design solution through use of evidence-based reasoning • Justify why their design solution is appropriate based on application of core science/mathematics concepts • Justify why their design solution is appropriate based on information obtained in problem scoping

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Overview

Materials * required materials not included in the kit	Duplication Masters
• **Per Class:** 2 - large containers to hold water * (length and width need to be larger than 14 x 14”,height is flexible), 2 - weights to act as loons during testing, 2 - Rolls of Aluminum foil (cut into 12 x 12” squares), Roll of wax paper (cut into 12 x 12” squares), package of playing card, 2 - packages of pipe cleaners (100 per pack), 2 - packages of wooden stick (100 per box), 2 - Stop watches/timers, 1 - Roll of duct tape, 1 - Roll of masking tape, 1 - Roll of bubble wrap (cut into 12 x 12” squares), 2 - Packs of straw (100 per box), 1 - box of Ziploc sandwich bags, 100 per box • **Per Group:** Scissors, Ruler, 1 - Hot glue gun, 4 - Sticks of hot glue, Bag of Spanish sheet moss, 0.5 oz, Bag Plastic Easter grass, 0.5 oz, Hay/straw, 0.5 oz, Soil, 0.5 oz, 1 - Corrugated cardboard, 12 x 12” per sheet, Plastic grid sheet, 12 x 12” per sheet, Foam sheet, 5.5” x 8.5” per sheet, 8 oz per bottle, 6 - Ping pong balls, 6 - Dixie cup (plastic 3 oz), 6 - 2 oz sauce containers • **Per Student:** 1 - Paper Clip, 1 –Engineering Slider, 1 – Engineering Notebook, different colored Pens/ Pencils	• 6.a. Your Best Nest Platform Design: Individual Plan • 6.b. Evidence-Based Reasoning Graphic • 6.c. Your Best Nest Platform Design: Group Plan • 6.d. Your Best Nest Platform: Final Scoring Guide **EDUCATOR RESOURCES** • 6.e. Teacher Observation Protocol: Try Lesson • 6.f. Teacher Observation Protocol: Test Lesson
• **Per Class:** 2 - large containers to hold water * (length and width need to be larger than 14 x 14”,height is flexible), 2 - weights to act as loons during testing, 2 - Rolls of Aluminum foil (cut into 12 x 12” squares), Roll of wax paper (cut into 12 x 12” squares), package of playing card, 2 - packages of pipe cleaners (100 per pack), 2 - packages of wooden stick (100 per box), 2 - Stop watches/timers, 1 - Roll of duct tape, 1 - Roll of masking tape, 1 - Roll of bubble wrap (cut into 12 x 12” squares), 2 - Packs of straw (100 per box), 1 - box of Ziploc sandwich bags, 100 per box • **Per Group:** Scissors, Ruler, 1 - Hot glue gun, 4 - Sticks of hot glue, Bag of Spanish sheet moss, 0.5 oz, Bag Plastic Easter grass, 0.5 oz, Hay/straw, 0.5 oz, Soil, 0.5 oz, 1 - Corrugated cardboard, 12 x 12” per sheet, Plastic grid sheet, 12 x 12” per sheet, Foam sheet, 5.5” x 8.5” per sheet, 6 - Ping pong balls, 6 - Dixie cup (plastic 3 oz), 6 - 2 oz sauce containers • **Per Student:** 1 - Paper Clip, 1 –Engineering Slider, 1 – Engineering Notebook, different colored Pens/ Pencils	• 7.a. Your Best Nest Platform Redesign • 7.b. Scoring Rubric • 7.c. Evidence-Based Reasoning Graphic **EDUCATOR RESOURCES** • 7.b. Scoring Rubric

Overview

	Material	Lessons Where Material is Used
Per classroom	20 Large Poster Paper	1,2, 3, 4
	2 large containers to hold water * (length and width need to be larger than 14” x 14”, height is flexible)	6, 7
	2 weights to act as loons during testing	6, 7
	1 Roll of aluminum foil (cut into 12” x 12” squares)	6, 7
	1 Roll of wax paper (cut into 12” x 12” squares)	6, 7
	1 package of playing card	6, 7
	1 package of pipe cleaners (100 per pack)	6, 7
	1 package of wooden stick (100 per box)	6, 7
	2 Stop watches/timers	6, 7
	1- 2 Rolls of duct tape	6, 7
	1- 2 Rolls of masking tape	6, 7
	1- 2 Rolls of bubble wrap (small bubbles - 12” x 12” squares)	6, 7
	2 Packs of straws (100 per box)	6,7
	1 box of Ziploc sandwich bags, 150 per box	1, 6, 7
	Plenty of Sticks of hot glue	6, 7
	Spanish sheet moss, 8-12 oz	6, 7
	Plastic Easter grass, 8-12 oz	6, 7
	Hay/straw, 8-12 oz [small bail]	6, 7
	1 bag of Soil, 1 lb.	6, 7
	20 sheets of Corrugated cardboard, 12” x 12” per sheet	6, 7
	20 Plastic grid sheet, 12” x 12” per sheet	6, 7
	20 Foam sheet, 5.5” x 8.5” per sheet	6, 7
	40-50 Plastic bottles, 8 oz per bottle	6, 7
	40-50 Ping pong balls	6, 7
	1 box of Dixie cup (plastic), 4 oz (100 count)	6, 7
Per group (assuming 3 students per group)	1 Box of markers (6-8different colors)*	2, 3, 4
	1 Tape /Glue*	2, 3
	1 Scissors*	2, 3, 5, 6, 7
	1 Ruler*	5, 6, 7
	1 Compass	5
	1 Hot glue gun	6, 7
Per student	15-1 cm/1 g/1 mL cubes as marking materials	1
	1 Dry erase marker*	1
	1 Pack of sticky notes*	1, 2, 4
	1 Engineering Notebook*	1-7
	1 Engineering Design Process slider with Jumbo paper clip*	1-7
	1 pen/pencil*	1-7
	1 Sheet of paper (8.5 x 11”)*	2
	1 Computer **	3
	1 Sheet of graph paper	4
	1 Sheet of construction paper*	5
	1 Calculator	5, 6, 7

* required materials not included in the kit

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LESSON 1

Move It or Lose It

Lesson Objectives

The students will be able to:

- Identify different ways that humans have impacted wildlife and the environment
- Categorize and rank human impacts on the environment
- Define the problem based on the client's needs
- Describe the problem based on a synthesis of information
- Explain why the problem is important to solve based on evidence
- Describe the relevant client needs based on evidence
- Identify the relevant end user
- Describe the background knowledge needed to develop a solution
- Describe criteria and constraints based on synthesis of given and found information
- *For a complete list of the Objectives see the Overview*

Time Required

Two 54-minute class periods

Materials

- **Per Class:** 1 Poster paper
- **Per Student:** 15 cm/1 g/1 mL, 1 Ziploc sandwich bag, 1 Dry erase marker, 1 Pad of sticky notes, Engineering notebook, Engineering slider with paper clip, Different colored pens/pencils

Standards Addressed

- Next Generation Science Standards: MS-ETS1-1, MS-LS 2-4

Key Terms

environment, habitat, ecology, human impact, shoreline development

Lesson Summary

Students will brainstorm different ways that humans have impacted the environment. They will learn about shoreline development and will be presented with the engineering challenge.

Background

Teacher Background

This lesson encourages students to consider how humans impact the environment around them. First, a class brainstorming session helps students build upon their existing knowledge regarding human impact. Next, students categorize human impacts by type: impacts on the land, air, water, and species. Through the form of a game, students then focus on the impact that humans have on common loons, especially on the shorelines of lakes.

After seeing how humans impact the habitat of the common loon, students are introduced to the engineering design cycle as presented by the EngrTEAMS Process of Design. They are also introduced to the engineering design challenge, which is designing and building a floating nesting platform for loons. The challenge comes in the form of a memo from the Minnesota Department of Natural Resources. Students critically read the memo to gather information about the design challenge, as well as about the needs of common loons. From there, they are asked to complete the "Understanding the Problem" assessment. This assessment addresses the aspect of the engineering process of design referred to as "Problem Scoping."

A brief description of the steps of the engineering design process follows. More information on this topic can be found in the front matter on page 5. Engineers design solutions to meet demonstrated needs and improve lives. Steps of this iterative process typically include: 1) Define the problem and identify the client, end user (if applicable), and any criteria and/or constraints specified for the solution; 2) Learn about relevant ideas and information, including previous solutions and how they could be further improved; 3) Plan potential solutions and consider trade-offs of the different options; 4) Try out the solution that seems most appropriate, figure out how to minimize risk, and build a model or prototype to test; 5) Test out the potential solution, developing a hypothesis and collecting and analyzing data to support or refute it; and 6) Decide upon a design, considering test results, client criteria and constraints, and potential improvements. If the design could be further improved, the cycle is repeated. Throughout this process engineers are involved in teamwork and communication, which are also two key practices in scientific inquiry. Claims regarding the efficacy of any solution should always be supported by evidence from tests and/or background knowledge.

Over the course of the unit, students should be continually reminded of the aspects of this process. It is also important to emphasize productive teamwork, evidence-based reasoning, and learning from failure. While engineers try their best to have a good plan before they test their solution, failure represents an opportunity for redesign. Refer to the appropriate step on the Engineering Design Process Slider at each lesson to help students orient themselves and reconnect to the bigger picture of the engineering design challenge.

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Move It or Lose It

Teamwork notes: Before beginning the unit, organize students into teams (groups of 3-4 work best). Students will remain with the same team for the entirety of the unit. If possible, assign roles to individual team members to ensure participation from all students. Possible roles include Recorder, Discussion Facilitator, Timekeeper, and Reporter.

Before the Activity
Prepare materials for game (each student will need 15 cubes to act as space markers and 1 game board):

- Game pieces: Place 15 cubes (1 cm/1 g/1 mL) in a Ziploc sandwich baggie. Students will use the cubes as marking chips for the game.
- Game board: So that the game board may be used multiple times, print the "*We Built This City*" game board template on cardstock and then laminate it.
- Dry-erase marker: So that the game board may be used multiple times, ask students to use a dry-erase marker to mark off spaces that are called during the game.

Find a video clip online or pictures of loons.

Prepare handouts. Each student will need 1 copy of each of the following worksheets:

- What do you know about human impact?
- We Built This City Reflection
- Memorandum
- Define and Learn Questions for gluing/taping into Engineering Notebook (or you may show questions on screen for students to answer)

Classroom Instruction

Day 1
Part 1: Human Impact (setting the stage for the unit)
Introduction

1. **Introduce the context of the design challenge**. Ask the following question: *How have humans changed things for wildlife?* Give students ample time to think, pair up, and verbally share their answers with a peer.

Activity

1. **Brainstorm about human impacts.** Hand out the *1.a. What do you know about human impact?"* brainstorming sheet. **Note:** The categories students will use to organize their responses (impacts on air, water, land, and organisms).
   - As a class, brainstorm examples of human activities that affect the environment. Include both positive and negative examples (e.g., mining, dumping garbage, driving cars, urban development, farming, planting trees, etc.)
   - Ask students to individually sort examples from the list into the different categories and record their responses on the worksheet.
   - Ask students to compare their ideas with tablemates or 1-2 peers.
   - Ask the students to rank the different categories according to which

Assessments
Pre-Activity Assessment
During the brainstorming process, assess students' prior knowledge about different types of human impacts on the environment. Responses to the *"What do you know about human impact?"* Worksheet may also be used to assess this objective.

Students answer "*What do engineers do?"* and *"How do engineers solve problems?"*

Students list ideas of what engineering is and "share out" with the entire class.

Activity Embedded Assessment
Use the "We Built This City" reflection to determine whether students can describe negative human impacts on the loon population and generate potential solutions to the problem.

Post-Activity Assessment
Review answers to prompts to determine if students can identify the problem and its importance; client and their needs; the end user and their needs.
Use the EDP slider to determine if students can identify where they are in the engineering design process.

DUPLICATION MASTERS

- 1.a. What Do You Know About Human Impact?
- 1.b. We Built This City! (Board Game)
- 1.c. We Built This City Reflection
- 1.d. Memorandum
- 1.e. Problem Scoping Prompts

EDUCATOR RESOURCES

- 1.f. We Built This City Instructions

have the greatest human impact.
- Invite each group to share their rankings and explain their reasoning. Encourage students to provide evidence when justifying their claims on human impact in the different categories.

2. **Draw attention to the category "Organisms."** If students have not yet identified loons as organisms that might be affected by human activity, ask the students if they know about this animal. To further familiarize students with the loon, it may be helpful to show a video clip or pictures of a Common Loon (*Gavia immer*) in its natural environment. Note that loon populations are profoundly impacted by human activity. Tell students that they will be playing a game to simulate what happens when humans alter loon habitats. Tell students to glue the worksheet into their notebooks.

Part 2: "We Built This City" Activity
1. **Pass out materials.** Hand out a "We Built This City" game board and 15 markers (1 cm/1 g/1 mL cubes, chips, etc.) to each student.
2. **Explain how to play the game.** Use the instructions listed on the *1.f. We Built This City* educator resource sheet.
3. **Distribute the *1.c. We Built This City Reflection* worksheet.** Instruct students to complete the worksheet independently. Once students have finished, take time to share as a class. Encourage students to explain the thinking behind their predictions regarding the future of the loon population.
4. **Attach in the engineering notebook.** Have students glue the reflection worksheet in their engineering notebook.

Day 2
Part 3: Introduce the Engineering Challenge
1. **Review what the students have learned during the previous class.**
2. **Write answers to the notebook prompts.** Before introducing the engineering challenge to students, inform students that they will be working in teams as engineers. Ask them to think and individually write in their Engineering Notebook the following two questions from the *Define and Learn Engineering Notebook Questions*:
   - *"What do engineers do?"*
   - *"How do engineers solve problems?"*
3. **Have students share their ideas with the class.**
4. **Guide students to the following definition:** Engineers are people who use science and mathematics to provide creative solutions to problems.
5. **Introduce the engineering challenge** by asking the students to consider if the same issues that affected loon populations in the imaginary city also occur in real life. Share that the Minnesota Department of Natural Resources (DNR) is concerned that the local loon population has been affected by shoreline development. The Department has requested assistance from citizen-engineers to protect the loon habitat.
6. **Hand out the client *1.d. Memorandum*** and ask students to read it individually. Ask them to summarize to a partner what their job will be in the engineering challenge. Then, ask students to glue the memo into their engineering notebooks.
7. **Ask students to consider how an engineer might go about solving this problem.** Discuss student responses.

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8. **Distribute an Engineering Design Process Slider and a paper clip to each student.** Introduce the slider as a handy tool to help students track their progress towards completing the challenge of building an artificial loon nesting platform. Ask students to identify which step they think they are on in the engineering process of design (POD) and mark the step with their paper clip. Have them record where they are in the POD in their engineering notebooks.
9. **Have students answer the 1.e. Problem Scoping Prompts. First individually, then have the students share and discuss as a team.** Ask students to record their team's answers in their engineering notebook using a different colored utensil in the team space. You may choose to not use the 1.e. Problem Scoping Prompts worksheet and have them record the answers directly in the notebook. See the appendix for information about how to do that.
10. **Ask students to think about what additional client information they will need to solve the problem.** Ask students to write the following prompt for the Define and Learn Engineering Notebook Questions in their engineering notebook:
    - *What questions do you want to ask the client?*
11. **As a class, have students ask their questions to the client and then you will answer representing the client.** Students are to record the answers in their engineering notebook.

    Note: Make sure not to tell things that the students will be discovering in the lessons that follow. Specifically do not answer specific questions about the loon or about the materials they will have to design their solution. Tell the students that the client wants them to research the loon and that the client has not yet decided on the materials.

Closure

1. **Gather the students together as a class to synthesize their learning.**
    - Construct a two-column T-Chart labeled: *What do we know? What do we need to know?* (**Optional:** Create one T-Chart poster per team)
    - Distribute sticky notes to each student. Tell students to pick something that they know about the challenge and record it on one sticky note. Tell them to record any questions they have for the client on another sticky note. Ask students to place sticky notes in the appropriate column on the T-Chart.
    - Discuss students' responses. Request that students record the results of the discussion in their engineering notebooks.
    - Keep the T-Chart posted for the remainder of the unit. Refer back to the chart, updating it as needed.

LESSON 1

Name________________________________ Date___________ Period _____

1.a. What Do You Know About Human Impact?

Directions: First, sort the different ways humans impact the environment into the categories in the table. Next, rank the categories with numbers 1-4 (1 being the greatest human impact and 4 the least).

Category	Human Impact	Rank Categories (1-4)
Air		
Water		
Land		
Organisms		

Which category do you think has the greatest human impact from your rankings? _________
Using complete, descriptive sentences, explain why you think it has the greatest impact. Provide two pieces of evidence that support your claim.

Which category do you think has the lowest human impact? ________________________
Using complete, descriptive sentences, explain why you think it has the least impact. Provide two pieces of evidence that support your claim.

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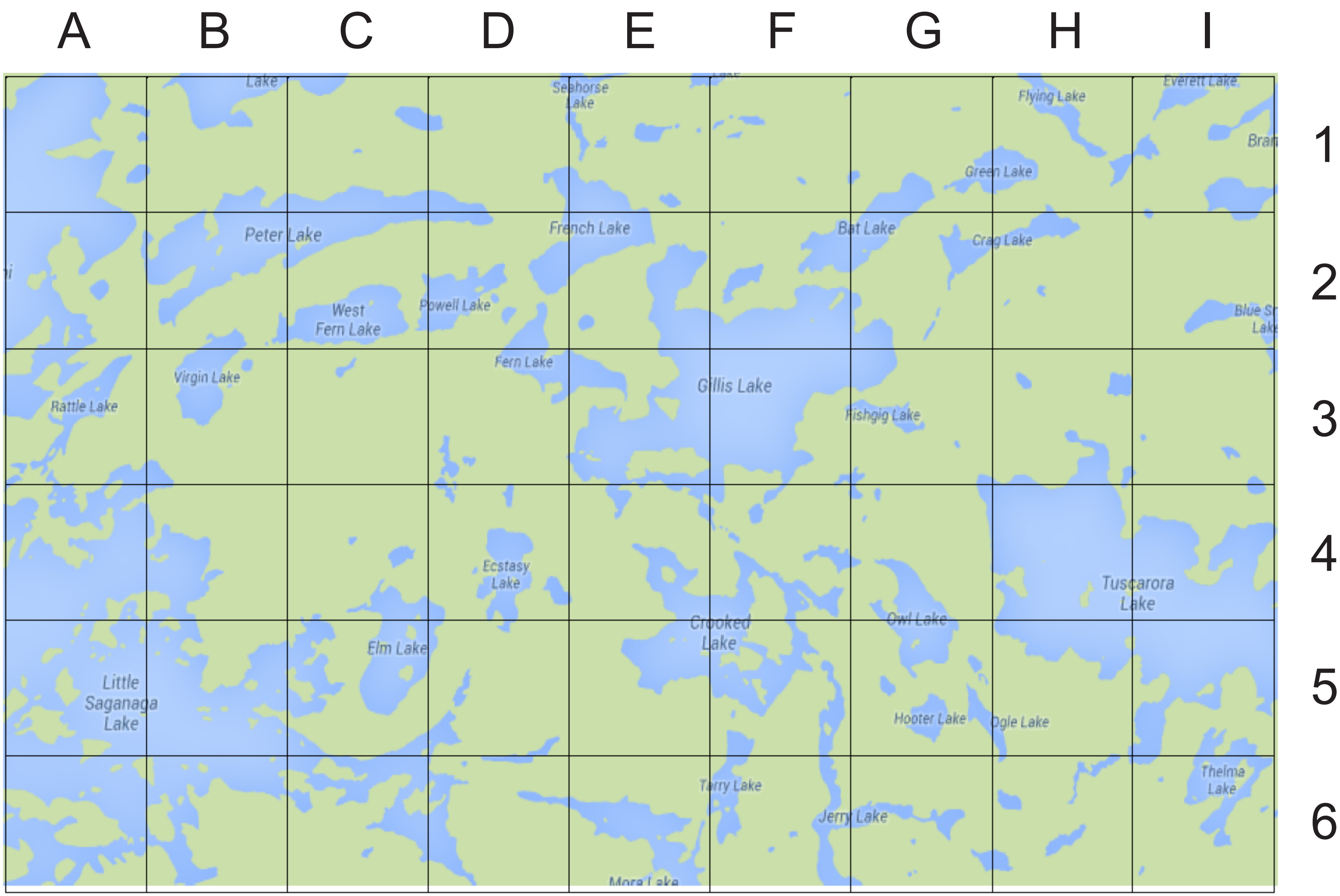
LESSON 1

Name________________________________ Date___________ Period _____

1.b. We Built This City! (Game Board)



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LESSON 1

Name________________________________ Date___________ Period _____

1.c. We Built This City Reflection

1. How many loons do you have left on your grid? ____________________

2. Which building/land development project was the most detrimental/harmful to the loon population?

3. Predict what will happen to the loons over time if humans continue to develop the land at this rate.

4. What do you think are some possible solutions to this problem?
   a.

   b.

   c.

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LESSON 1

Name________________________________ Date___________ Period _____

1.d. Memorandum

To: Research Team

From: Dr. River Banks, Wildlife Biologist, Minnesota Department of Natural Resources

Subject: Common Loon Nesting Platform Research

Biologists at the Minnesota Department of Natural Resources have been monitoring shoreline development of Minnesota lakes and rivers for many years. By doing so, the researchers hope to learn more about how human shoreline habitation affects plant and animal species in these environments. In the past few years, a few of our biologists have focused on how human activity impacts the common loon.

Minnesota's state bird, the common loon (*Gavia immer*), is a species of bird that subsists mainly on small fish. Loons are characterized by long, heavy bodies, rounded heads, and dagger-like bills that help them catch fish as they dive. Recent survey efforts show their population has remained fairly stable in Minnesota. However, increasing human activity on lakes is a cause for concern.

The Common Loon's preferred environments for breeding and nesting are quiet lakes in the northern United States and Canada. Loons are extremely sensitive to human activity and will not breed if there is too much. Their ideal nesting habitat is an undeveloped lake shoreline with little or no high-speed boat traffic. As humans build up the shorelines of even the most remote lakes in Minnesota, this presents a problem for loons trying to breed. People unknowingly destroy prime loon nesting habitat when they change the shoreline of their cabin to make a beach or lawn. Loons that nest on popular lakes are often forced to abandon their nests when boaters and jet skis get too close and come by too frequently.

The Minnesota Department of Natural Resources is researching alternate nesting sites for the common loon, in an attempt to keep the population from dropping as human activity increases. Common loons are faced with many other threats, such as climate change and avian malaria, which are more difficult for us to control. We seek your help to design a floating platform on which loons will be able to build their nests in the absence of suitable lake shoreline. Ideally, we are looking for an inexpensive nesting platform prototype that can eventually be mass-produced and is suitable for loons. We also need you to choose a suitable metropolitan lake on which to test your platform.

We look forward to reviewing your solutions.

Sincerely,

River Banks

Dr. River Banks

LESSON 1

Name________________________________ Date___________ Period _____

1.e. Problem Scoping Prompts

First, **on your own**, answer each of the following questions beside the "My Response" space. Then, in your teams, each person is to share their response and discuss. In the space, "Team Response" **write your revised answer to the question**, based on discussion with your team. You may use a different color writing utensil to distinguish your answer and how it changed after talking with teammates.

1. **Who is the *client*?**
   My response:

   Team response:

2. **What is the client's *problem* that needs a solution?**
   My response:

   Team response:

3. **Why is the problem important to solve?**
   My response:

   Team response:

4. **Who are the *end-users*?**
   My response:

   Team response:

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Name______________________________ Date__________ Period _____

1.e. Problem Scoping Prompts

5. **What are the *needs of the end-user*?**
   My response:

   Team response:

6. **What will make a solution effective *(criteria)*?**
   My response:

   Team response:

7. **What will limit how you can solve the problem *(constraints)*?**
   My response:

   Team response:

8. **Think about the problem of human encroachment on loon nesting sites. What do you *need to learn* in order to select a suitable lake and build a loon nesting platform?**
   My response:

   Team response:

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1.f. We Built This City Instructions

1. Explain that the grid represents an area where humans have not been living and therefore have not developed the land.
2. Instruct students to randomly scatter their 15 markers on the grid. Explain that the cubes represent the natural loon population that lives in this area.
3. To play the game, "call out" different boxes on the grid (see calls below). Tell students that this land has been bought up and is going to be developed by humans. If the box is called, ask students to remove any markers that are in the box and draw an "X" in the box using the dry-erase marker. If a loon is in a box where humans develop the land, that loon population can no longer stay there.
   - 1st call – A shopping mall is built in E4
   - 2nd call – A school is built in B2
   - 3rd call – A parking garage is built in B5
   - 4th call – The forest is cut down in A1 for home construction
   - 5th call – A strip mall is built in E3
   - 6th call – An apartment building is built in D2
   - 7th call – An amusement park is built over C2, C3, and C4.
   - 8th call – a Big Box store is built in D4
   - 9th call – Cabins are built around the lake shores of F4
   - 10th call – Fast food restaurants are built in B4
4. Have the students count the number of loons (markers) they have left on the map. Ask one or two students to share their results with the class.

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LESSON 2

Loon-ey Tunes

Lesson Objectives
The students will be able to:
- Summarize basic characteristics of Common Loons based on the results of a scavenger hunt
- Define key vocabulary terms, represent the relationships between them
- Describe the needs of the end user
- Describe the background knowledge needed to develop a solution

Time Required
One 54-Minute class period

Materials
- **Per Class:** none
- **Per Group:** 1 Poster paper, 1 Pack of Markers, 1 Glue stick, 1 Pair of scissors
- **Per Student:** 1 8.5 x 11" sheet of paper, 1 Pad Sticky Notes, Engineering Notebook, Engineering Slider with Paper Clip, Different colored Pens/ Pencils

Standards Addressed
- Next Generation Science Standards: MS-ETS1-1

Key Terms
organism, population, community, ecosystem

Lesson Summary
Students will go on a scavenger hunt to learn basic information about common loons. After the scavenger hunt, students will define and represent the relationship between the key vocabulary terms ecosystem, community, population and organism.

Background
Teacher Background
In this lesson, students gain background knowledge about the common loon (*Gavia immer*). For students who live outside of Minnesota, this lesson will provide critical information about loon characteristics, behaviors, and habitat. This information will assist them in solving the engineering design challenge. Students also predict the meaning of different loon calls and check their predictions. The four loon calls presented are: hoot, tremolo, wail, and yodel. Through the information presented in the scavenger hunt, students learn about how loons fit into a larger ecological structure. Terms defined are organism, population, community, and ecosystem. By the end of the lesson, students should be able to identify examples of the terms and explain why they correspond to the definitions created in class.

The common loon is one of five species of loons, a group of diving birds whose relatives first evolved around 25 million years ago. It is only loon species found in the mainland United States; however, all five species are present in Alaska. The common loon is known for its characteristic vocalizations and striking summer plumage. Male and female adults have black and white spotted feathers and red eyes. Between April and September common loons nest and breed on the shoreline of inland lakes in the upper Midwest and Canada. They build their nests from surrounding grasses, twigs, and reeds. Loons typically lay 2 eggs each time they nest; they rarely nest more than once a season. The eggs hatch about a month after they are laid, between June and early August. Young loons can swim 3 days after they hatch, but cannot fly until they are over two months old. Loons migrate south starting in late August and early September. They spend their winters between the Atlantic coast and the northern Gulf of Mexico. Although comparatively little is known about loon behavior and ecology in the off-season, loons in Minnesota and Wisconsin have been extensively researched. The total common loon population in Minnesota is approximately 12,000 birds. Loons mostly subsist on fish, such as smelt, minnows, trout, and perch. Occasionally, they eat insects, crayfish, and leeches.

As of May, 2016, additional concise background information on loons can be found through the Minnesota DNR (www.dnr.state.mn/us/birds/commonloon.html) and the Audubon Society electronic Field Guide (www.audubon.org/field-guide/bird/common-loon). More extensive information about the Wisconsin loon population, including detailed pages on phenology and behavior, can be found at Northland College's Sigurd Olson Environmental Institute Loon Watch Program site: (vhost2.wiscnet.net/sigurd-olson-environmental-institute-loon-watch.htm).

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Loon-ey Tunes

Notes:

- Showing a portion of this video clip (available as of May, 2016 at http://www.youtube.com/watch?v=MXdihx70H1g) may help students understand why loons need a lot of space for taking flight from a lake.
- Helpful information about the common loon can be found at the following site (as of May, 2016): http://www.learner.org/jnorth/search/Loon.html
- Color-coding the scavenger hunt clues—so that one color represents Loon "body information", one represents "habitat information", and one represents "nesting information"—may assist some students.
- Answers to loon calls: Tremolo (D), Wail (B), Yodel (A), Hoot (C)

Before the Activity

- Print and copy All About Loons worksheet (1 per student)
- Prepare *2.b. Scavenger Hunt Clues.* Place them in different areas around the classroom or school.
- Prepare 4-6 Power Point slides or print pictures that allow students to identify vocabulary terms: organism, population, community and ecosystem.
- Prepare video links to the 4 Loon calls. As of May, 2016, the four calls mentioned can be found at the following addresses: http://www.learner.org/jnorth/tm/loon/identification.htmlhttp://www.learner.org/jnorth/tm/loon/identification.html or https://www.allaboutbirds.org/guide/common_loon/sounds

Classroom Instruction

Introduction

1. **Remind the students about the engineering design challenge.** Ask a volunteer to restate the challenge (building an artificial nesting platform).
2. **Ask students to identify where they are in the design process using the Engineering Design Process Slider.**
   Note: The next step is to learn important background information on the problem.
3. **Ask students to identify the end user** of the platforms (the loons).
4. **Briefly ask students to share what they know about loons.**
   Say: *Today we are going to learn more about loons.*

Activity

1. **Display the following table to the class.**

Match each loon call with its purpose. Don't be afraid to take a guess!	
Tremolo ________	A. A territorial call
Wail ________	B. To find out another loon's location
Yodel ________	C. To keep in contact with each other
Hoot ________	D. To announce its presence or when it is alarmed

Answers: D, B, A, C,

2. **Play the 4 loon calls.** Ask students to guess which call is which and to write their answers down in their notebook. Once all calls have been played, share the correct answers with the students.

Assessments

Pre-Activity Assessment
Restating the challenge.

Activity Embedded Assessment
Monitor student progress during the scavenger hunt.

Assess students' ability to correctly match vocabulary terms to corresponding pictures.

Post-Activity Assessment
Using the questions in the lesson closure and the Post-It chart, assess students' ability to apply new knowledge about loons to the engineering design problem.

DUPLICATION MASTERS

- 2.a. All About Loons! Scavenger Hunt

EDUCATOR RESOURCES

- 2.b. Scavenger Hunt Cards
- 2.c. Foldable Vocabulary Tool

3. **Distribute the *2.a. All About Loons* worksheet.**
4. **Conduct the Scavenger Hunt.** Direct students to complete the "Guess Before" column on their *2.a. All About Loons* worksheet by indicating whether each statement is True or False. Direct students to find the *2.b. Scavenger Hunt Clues* that have been placed around the classroom or school. Tell students that these cards contain information that will help them confirm or revise their initial guesses. Remind students to write the correct True or False answer for each statement in the "Correct Answer" column.
5. **Discuss the correct answers to the scavenger hunt.** When students return, ask several students to share one or two new things that they learned in the course of the activity.
6. **Introduce key vocabulary terms.** Write or display the terms ecosystem, community, population, and organism. Ask students to record these terms in their notebooks. Invite them to share what they know about the terms. Extend students' responses with examples from the loon's ecology (see Background section for ideas). Guide them towards consensus on the definition of each term.
7. **Students create a foldable vocabulary tool.** Tell students that these terms are important to remember and understand. **Say:** *To help us remember which term is which and how they are connected, we will create a vocabulary tool that represents the relationships between them.* Distribute one blank sheet of 8.5 x 11" paper to each student. See the *2.c. Foldable Vocabulary Tool* educator resource for images of examples of the tool.
8. **Model creating the foldable vocabulary tool while verbally explaining the directions.**
   - **Say:** *When the paper is in landscape orientation, fold the ends until they meet. You will have made two quarter-folds, leaving half the paper in the center. Cut each of these folds in half with scissors until the crease. Inside the center section, draw 4 concentric circles that nest inside each other. Label each circle with a term, from the most specific to the most inclusive.*
   - Ask students to guess which term should go with which circle and why (e.g., the smallest circle is the organism because it refers to an individual; the largest circle is an ecosystem because it includes multiple populations).
   - Ask students to write one vocabulary word on each of the outer flaps of the foldable and to record the corresponding class definitions on the inside of the flaps.
   - See attached pictures for the foldable and circle diagrams
9. **Assess student understanding.** Show several pictures from different ecosystems that correspond to the vocabulary terms. Ask students to identify which term is represented in the picture and to explain their thinking.

Closure

1. **Provide three prompts for students to answer in their engineering notebook:**
   - *Summarize what you have learned about loons today (include at least three specific things).*
   - *Explain how this information may help you solve the engineering design problem.*

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- *What is the difference between a population and a community? How does this distinction apply to the loons in our design challenge?*

2. **Revisit the Post-It T-chart from Lesson 1.** Ask students to move or add Post-Its as needed.

LESSON 2

Name________________________________ Date___________ Period _____

2.a. All About Loons! Scavenger Hunt

Directions: Read each statement about loons below. Complete the "Guess Before" column by stating whether you think the statement is true or false. Then, go on a scavenger hunt to find the answers! When you do, record them in the "Correct Answer" column.

Guess Before (True or False)	Statement	Correct Answer (True or False)
	1. Loons can nest on any size lake.	
	2. Loons prefer fish that swim in a straight line because they are easier to catch.	
	3. Common loons need lakes that are very clear.	
	4. Common loons usually lay 6 eggs.	
	5. Raccoons can be predators of Common loons.	
	6. Loon chicks are usually black with white bellies.	
	7. Loon chicks are not ready to be in the water for 2 weeks after hatching.	
	8. Most birds have hollow bones but loons do not.	
	9. Loons spend most of their time on land and only go into water to feed.	
	10. Common loons stay in Minnesota for the winter.	
	11. Loons sit on their nest and incubate eggs for about 26-29 days.	
	12. Loon eggs are small and white like chicken eggs.	
	13. Common loons can weigh as much at 6.1 kg (about 14 pounds). This is the same as an adult Bald Eagle.	
	14. Male and female Common loons look very different.	
	15. Only female loons incubate the eggs on the nest.	
	16. Common loons look the same all year round.	

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2.b. Scavenger Hunt Cards

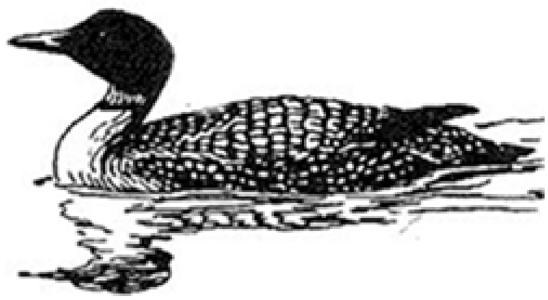
Loon-ey Tunes

Loon eggs are large and brown with dark spots.

- Egg length: 9 cm
- Egg width: 5.5 cm

2.b. Scavenger Hunt Cards

Loon-ey Tunes



Loons prefer lakes that:

- have islands or coves (to provide protection when resting and nesting
- are large lakes (they need a lot of space to run and take off for flight)

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Loon-ey Tunes

Loon chicks are able to swim and ride on their parents' back a few hours after hatching from the egg. However, they cannot fly for two months.

The chicks are mostly black with a white belly.

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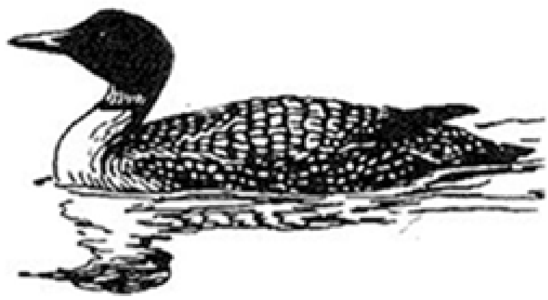
2.b. Scavenger Hunt Cards

Loon-ey Tunes



Loon legs are located very far in back of their bodies. They have a hard time moving on land. They spend most of their time in water.

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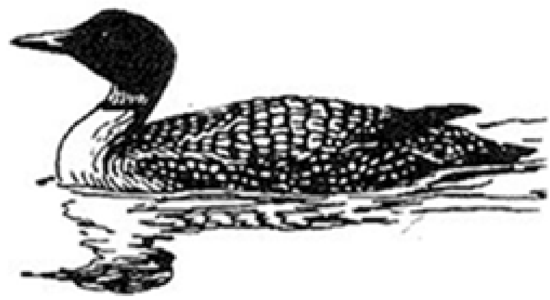
2.b. Scavenger Hunt Cards

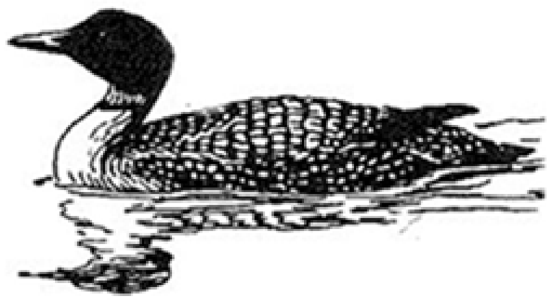
Loon-ey Tunes



Common loons migrate in the fall and live on the coasts of the Atlantic Ocean and Gulf of Mexico in the winter.

2.b. Scavenger Hunt Cards

Loon-ey Tunes



Male and female loons look almost exactly alike but males are usually larger.

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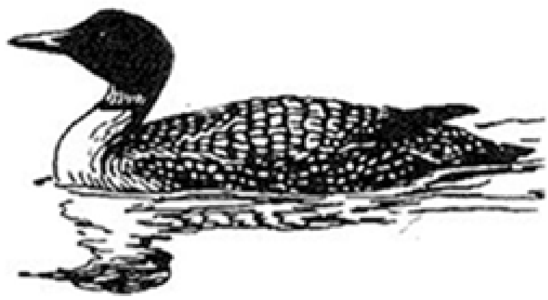
Loon-ey Tunes

Male and female loons spend about an equal amount of time sitting on the nest and incubating the eggs.

2.b. Scavenger Hunt Cards

Loon-ey Tunes



Common loons sit on the nest and incubate their eggs for 26-29 days.

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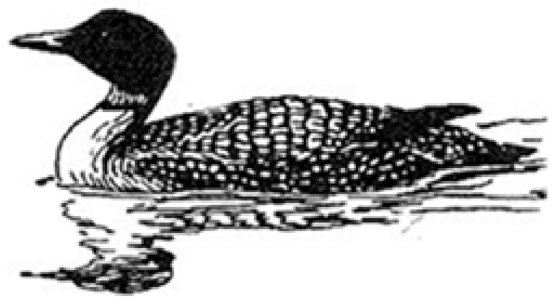
2.b. Scavenger Hunt Cards

Loon-ey Tunes

Most birds have hollow bones to make them lighter for flying, but loons are large and heavy birds because they have solid bones. This makes them better divers in the water.

2.b. Scavenger Hunt Cards

Loon-ey Tunes



Loons are visual hunters. They need very clear water so they can see their prey. The lakes that loons choose usually have at least 3 m of visibility.

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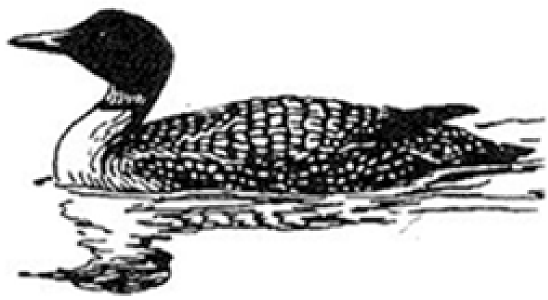
Loon-ey Tunes

Common loons do not look the same all year round. The loon feathers you are used to seeing is the "breeding plumage."

2.b. Scavenger Hunt Cards

Loon-ey Tunes



Loons prefer fish that do not swim straight line like:

- Yellow perch
- Pumpkinseed
- Bluegill

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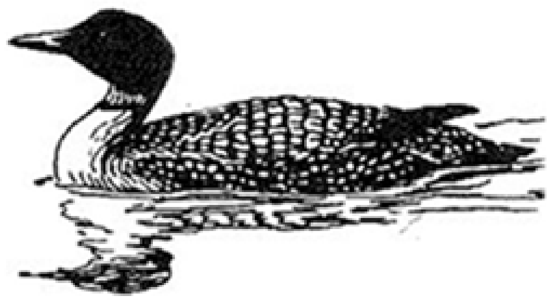
2.b. Scavenger Hunt Cards

Loon-ey Tunes

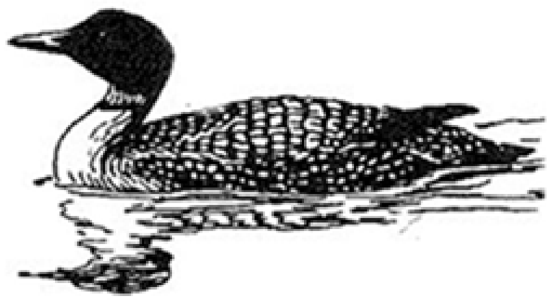


Size of common loons:

- Length: 66-91 cm
- Wingspan: 104-131 cm
- Weight: 2.5-6.1 kg

2.b. Scavenger Hunt Cards

Loon-ey Tunes



Loons usually lay two eggs, but sometimes either 1 or 3. Often only 1 chick survives even if they lay 2!

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2.b. Scavenger Hunt Cards

Loon-ey Tunes

Loons do have some predators. They include:

- Birds: Gulls, Ravens, Bald Eagles
- Fish: Northern Pike
- Land Mammals: Raccoons, Weasels, Skunks

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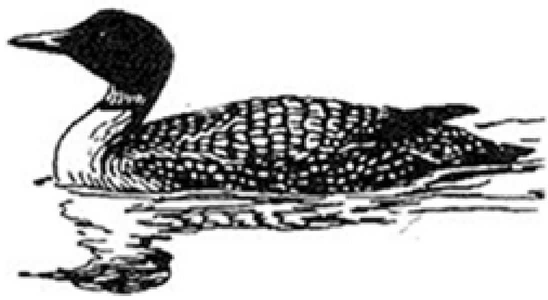
2.b. Scavenger Hunt Cards

Loon-ey Tunes



Loon have four different calls:

- *Tremolo:* To announce its presence or when it is alarmed
- *Yodel:* A territorial call
- *Wail:* To figure out another loon's location
- *Hoot:* To keep in contact with each other

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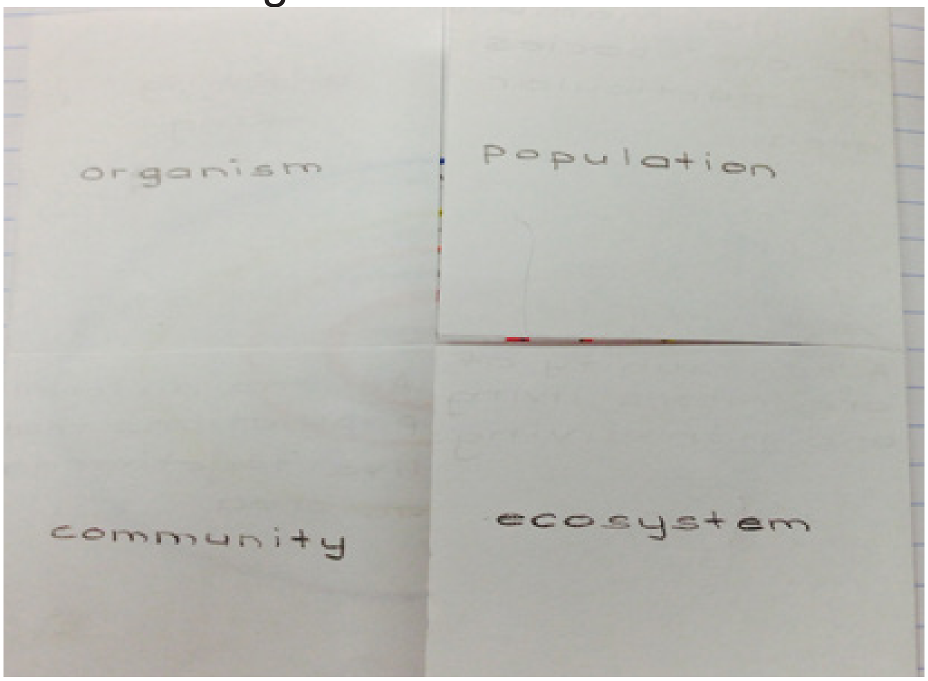
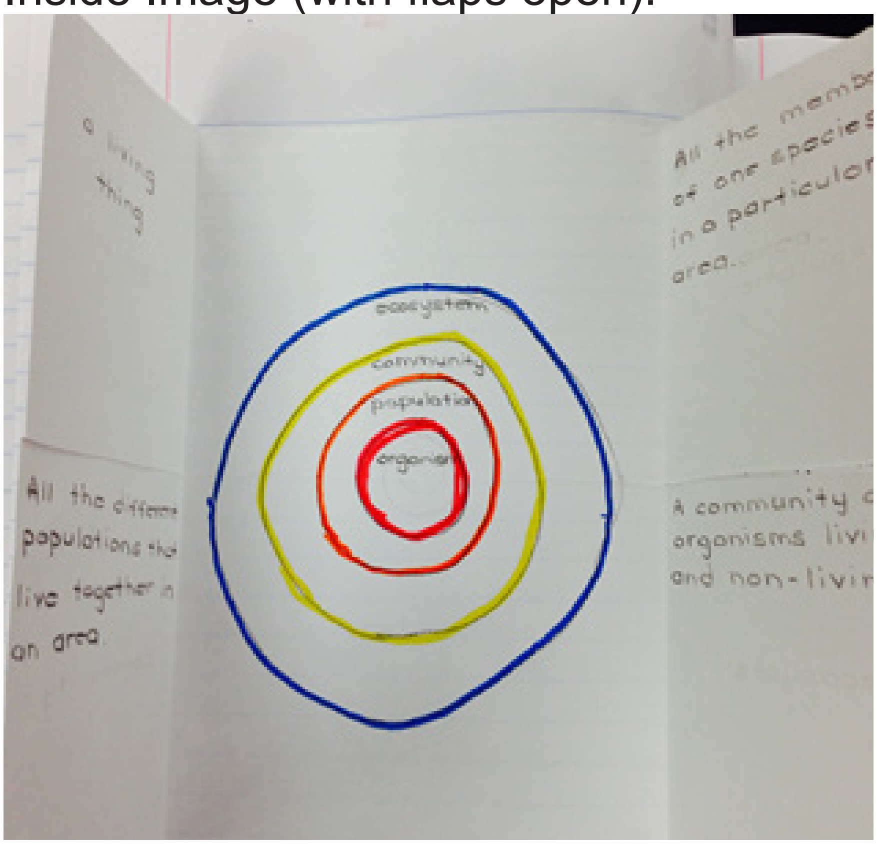
2.c. Foldable Vocabulary Tool

Outside Image:



Inside Image (with flaps open):



LESSON 3 What's for Dinner?

Lesson Objectives

The students will be able to:

- Differentiate between producers, consumers, and decomposers
- Create a food chain
- Create a food web
- Describe how energy flows through a food chain and a food web

Time Required

Three 54-minute class periods

Materials

- **Per Class:** none
- **Per Group:** 1 Large Poster Sheet, 1 Pair of scissors, 1 Ziploc sandwich bag, 1 Tape/Glue, 1 Box of Markers, 1 Organism Reference Sheet, 1 – Organism Cards
- **Per Student:** 1 Computer** [***Note:*** Reserve Computer Lab], Engineering Notebook, Engineering Slider with Paper Clip, Pens/Pencils

Standards Addressed

- Next Generation Science Standards: MS-LS 2-3

Key Terms

food chain, food web, producers, consumers, decomposers

Lesson Summary

Students will investigate the concept of food chains and food webs and the different roles that organisms play in them.

Background

Teacher Background

This is a lesson about food chains, food webs, and the roles that organisms play in each. Students may come with some prior knowledge about what a food chain and a food web are, but may need guidance to organize their thoughts. The students will also explore an organism's role in a food web: are they a producer, a consumer, or a decomposer?

All organisms in an ecosystem interact with each other at all times. In these interactions, particular groups of organisms have roles that they play (often called their ecological niche). The plants in an ecosystem act as producers – they are able to rely on the sun to provide energy to make their own food through photosynthesis. All animals in an ecosystem are consumers – consumers cannot make their own food, and therefore rely on eating other organisms (plants or animals) to get energy. Decomposers are organisms that break down waste and other dead matter; they are responsible for putting nutrients back into the environment.

Food chains and food webs are representations that show energy flows between the three types of living organisms. A food chain diagrams a single flow of energy in an ecosystem. It will usually include a producer and up to three consumers; it can include a decomposer as well. All energy flows in one direction. A food web, on the other hand, shows many different directions that the energy can flow.

Both food chains and food webs include arrows pointing in the direction of the flow of energy. When creating a food web or food chain, students often reverse the direction of energy flow so that it points toward what the organism consumes rather than organism that obtains the energy. Therefore, extra attention should be paid to help students understand how energy moves through a food web and food chain.

Before the Activity

- Print and copy *3.a. Food Chain Game: Introduction* worksheets (2 pages; 1 per student)
- Print and copy the *3.b. Food Chain Fun on the Web* worksheet (1 page; 1 per student)
- Print and copy *3.c. Organism Cards* and cut into cards. Store in Ziploc bag (1 set per small group of students)
- Print and copy *3.d. Organism Reference Sheet* (1 set per small group)
- Reserve computer lab or laptop computers for the web-quest (only 1 day needed)
- Preview website with *Food Chain Game*: As of May, 2016, the game can be found at the following address: http://www.sheppardsoftware.com/content/animals/kidscorner/foodchain/producersconsumers.htm.
- Obtain a diagram of a complex food web to be used in an assessment

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prompt on Day 3 of this lesson.

Classroom Instruction
Day 1
Introduction

1. **Remind students about the engineering design challenge.** Review students' prior knowledge on ecosystems with a K-W-L chart to address the questions "What do I Know about ecosystems?, What do I Want to know about ecosystems?, and What have I Learned about ecosystems?" Have students create a three-column K-W-L chart in their engineering notebook. Ask them to answer the "K" and the "W" sections on this chart.

   Sample format for chart:

K	What do I **Know** about ecosystems?	
W	What do I **Want** to know about ecosystems?	
L	What have I **Learned** about ecosystems?	

2. **Introduce the topic. Say:** *Now that we have learned about the loon's habitat and what they like to eat, we need to take it a step further and see how everything in an ecosystem connects to everything else. We will be looking at the roles that each type of organism plays in a food chain and a food web.*
   Pass out *3.?. Food Chain Web Quest* worksheet. In the large group, introduce students to the website containing the *Food Chain Game*. As of May, 2016, this game as available at: http://www.sheppardsoftware.com/content/animals/kidscorner/foodchain/producersconsumers.htm. Guide students to the areas of the website they will need to use for the worksheet.

Activity

1. **Play the Food Chain Game.** Ask students to complete the *Food Chain Game* on the website as well as the accompanying worksheet. **Can't tell which worksheets you are referring to throughout this section.**

Conclusion

1. **Summarize the day.** When students have finished, regroup. Discuss any remaining questions. If needed, review the following vocabulary: food chain, food web, producer, consumer, and decomposer.

Day 2 and Day 3:
Introduction

1. **Introduce the activity.** Tell the students that today they will be making a

Assessments
Pre-Activity Assessment
Use the K-W-L chart to assess students' prior knowledge of ecosystems (K column).

Activity Embedded Assessment
Check the Web-Quest worksheet and group food web poster for students' understanding of differences between producers, consumers, and decomposers and the components of example food chains and food webs.

Post-Activity Assessment
Collect students' notebooks and review the K-W-L chart to check for students' understanding of the role of organisms in a food chain (L column).

Use closing questions to assess energy flow through a food chain/web.

DUPLICATION MASTERS
- 3.a. Food Chain Game: Introduction
- 3.b. Food Chain Fun on the Web
- 3.c. Organism Cards
- 3.d. Organism Reference Sheet

EDUCATOR RESOURCES
- none

representation of energy flows in the ecosystem with which the common loon interacts.

2. **Get students organized for the activity.** Split students up into groups of 2-3. Distribute the *3.c. Organism Cards* containing pictures of organisms; a large piece of poster paper and markers to each group.

Activity

1. **Students make their food web.** Ask students to lay out the *3.c. Organism Cards* and connect the organisms in a food web, without assistance or further direction. Explain that at this point, they are only using their prior knowledge to construct a rough draft of the food web.
   Note: Students should NOT glue or tape the cards down yet.
2. **Students share with others.** After students have had time to construct their rough draft of the food web, ask them share their results with at least one other group. Encourage groups to share what they know is accurate in their food web, as well as to share areas where they were less sure about accuracy.
3. **Students revise their food web.** Once all groups have shared, ask students to return to their small groups. Hand each group the *3.d. Organism Reference Sheet*, which contains information about each organism (e.g., diet, predators, habitat, and a general description). Allow time for students to revise their food webs based on this new information.
4. **Students make poster.** Once they are confident in the accuracy of their model, let students know they can affix the picture cards to the poster paper. Remind them to draw arrows that represent how energy flows through the food web. (Caution: It is common for students to draw arrows representing who eats whom rather than the energy flow.)
5. **Whole class share out.** Hang up completed posters. Ask each group to explain to the large group how they organized their poster, and to describe how the energy flows within their food web. Ask questions to team members to check for individual and group understanding. Example questions include:
   - *What kinds of organisms are producers in this food web?*
   - *What kinds of organisms are consumers?*
   - *If we were to add a Northern Pike to our food webs, where would you place it? Why would you put it there?*
   - *Which direction did you draw the arrows? Why?*

Closure

1. **Fill out the "L" in the K-W-L Chart.** Ask students to fill out the "L" part of the K-W-L chart in their engineering notebook.
2. **Assess understanding.** Present the picture of a new food web. Ask students to answer the following prompts in their engineering notebooks:
   - *Identify a producer, a consumer, and a decomposer in the food web.*
   - *Diagram a possible food chain within the food web. Describe how energy flows through that chain.**

* Quiz option: You may choose to use the above as a more formal assessment.

* Post-it poster option

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LESSON 3

What's for Dinner?

LESSON 3

Name________________________________ Date___________ Period _____

3.a. Food Chain Game: Introduction

1. **Click** on the picture **"Parts of a Food Chain"** on the left side of the webpage. NAME OF WEBSITE
   Answer the following questions.

Producers:

- Why are they called producers?
- What type of living things are producers?

Consumers:

- Why are they called consumers?
- What type of living things are consumers?

Complete the chart with information about **3 main types of consumers** (you will want to click on the picture for each to get more information).

	What do they eat?	2 examples
Herbivore		
Carnivore		
Omnivore		

Decomposers:

- What do decomposers do?
- What are 2 types of decomposers?

2. **Play the Food Chain Game.**

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LESSON 3

Name____ Date____________ Period ______

3.a. Food Chain Game: Introduction

Directions: Go to the following link and play the game: <http://www.sheppardsoftware.com/content/animals/kidscorner/games/foodchaingame.htm>. Answer the questions below based on what you learn during the game.

Fill in the blanks using examples from the game.

A. Simple Food Chain

__________________ ➡ __________________ ➡ __________________

B. Marine Food Chain

__________________ ➡ __________________ ➡ __________________ ➡ __________________

C. What made the “Full Simple Chain” a complete circle? __________________________

D. What made the “Full Marine Chain” a complete circle? ___________________________

E. Chain with a human:

______________ ➡ ______________ ➡ ______________ ➡ ______________ ➡ ______________

3. Play the Producers, Consumers, and Decomposers Game.

Directions: Go to the link below and play the game. Answer the questions below based on what you learn during the game. http://www.sheppardsoftware.com/content/animals/kidscorner/games/producersconsumersgame.htm

Circle the correct answer.

A. cat	Producer	Consumer	Decomposer
B. mushroom	Producer	Consumer	Decomposer
C. flowers	Producer	Consumer	Decomposer
D. algae	Producer	Consumer	Decomposer
E. fish	Producer	Consumer	Decomposer

LESSON 3

Name________________________________ Date___________ Period _____

3.b. Food Chain Fun on the Web

Go to: http://www.sheppardsoftware.com/content/animals/kidscorner/foodchain/foodchain.htm

1. What does every living thing need? ______________________________________

2. Where do animals get the energy they need? __________________________________

3. What 3 things do plants use to get energy? _________________, _________________,

   ____

4. Fill in the blanks: A _________________ shows how each living thing gets food, and how

   _________________ and_________________ are passed from creature to creature.

   Food chains begin with_________________, and end with _________________. Some

   animals eat _________________, some animals eat other _________________.

5. List the three things that make up the simple food chain shown on the website (in the correct order):

6. Click to learn about **Bigger Food Chains** and fill in the blanks:

   So food chains make a full _________________, and energy is passed from plant to animal

   to animal to_________________ and back to _________________! There can be many

   links in food chains but not _________________ many. If there are too many links, then the

   _________________ at the end would not get enough _________________.

Cut and glue this sheet in your notebook.

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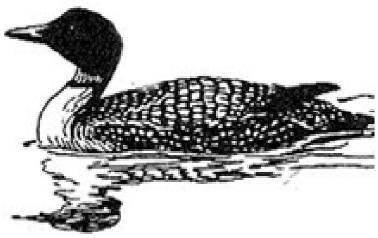
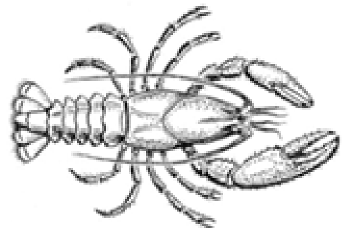
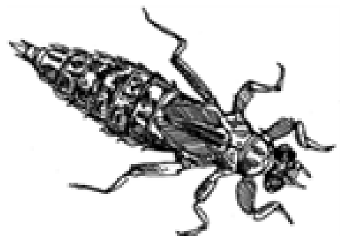
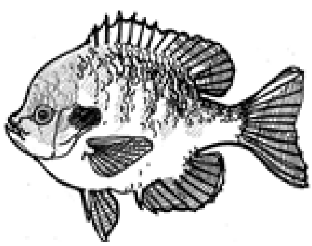
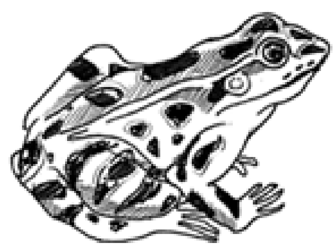
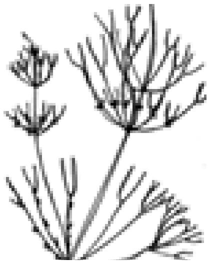
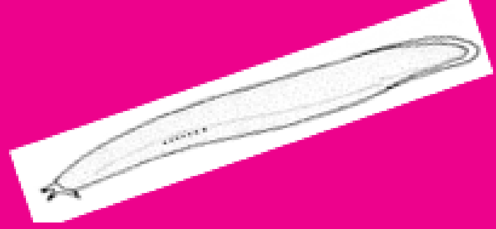
LESSON 3

Name____________________________________ Date____________ Period _____

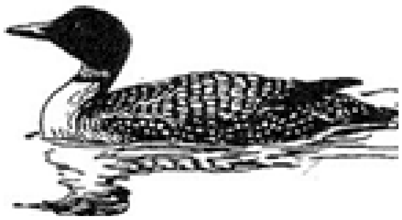
3.c. Organism Cards

Common Loon 	Crayfish 
Pondweed 	Dragonfly Larva 
Bluegill 	Northern Leopard Frog 
Bald Eagle 	Pocketbook Mussel 
Algae 	Leech (Replace with raccoon?) 

Name________________________________ Date___________ Period _____

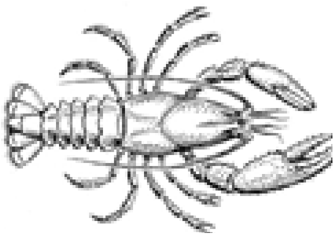
3.d. Organism Reference Sheet

Common Loon



- *Appearance:* Black and white pattern, rounded head, dagger-like bill, legs stick out behind the tail
- *Habitat:* Quiet, fresh water lakes in the northern United States; during migration – lakes and rivers in the southern United States
- *Diet:* Mostly fish (perch and sunfish)
- *Predators:* Gulls, northern pike, raccoons, skunks, Bald Eagles

Crayfish



- *Appearance:* 8 legs, 2 large claws, usually red or reddish-brown
- *Habitat:* Any freshwater area that isn't highly polluted (lakes, rivers, ponds, etcetera)
- *Diet:* Worms, insects, insect larva, fish eggs, frog eggs
- *Predators:* Raccoons, opossums, snakes, muskrats

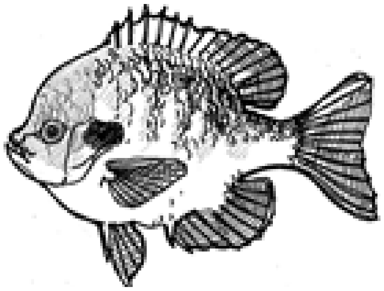
Sago Pondweed

- *Appearance:* Long, thin stems; long, feathery leaves; green
- *Habitat:* Any body of freshwater; on every continent except Antarctica
- *Diet:* Make sugar using energy from the sun (photosynthesis)
- *Predators:* Insects, insect larva

Dragonfly larva

- *Appearance:* 6 legs, no wings, has a small, crusty bump on its back
- *Habitat:* Bodies of freshwater; usually on plants in the water
- *Diet:* Other insect larva, underwater plants, tadpoles
- *Predators:* Birds, lizards, frogs, spiders, fish, waterbugs

Bluegill



- *Appearance:* Dark green color, blue color near the gills, usually have between 5 and 9 stripes on the sides of the body
- *Habitat:* Freshwater lakes, slow-moving streams and rivers
- *Diet:* Insect larva, crayfish, leeches, smaller fish
- *Predators:* Larger fish (northern pike, muskellunge, largemouth bass, walleye, catfish), birds (herons, loons)

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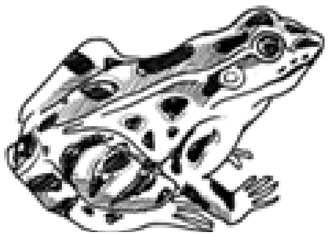
LESSON 3

Name______________________________ Date___________ Period _____

3.d. Organism Reference Sheet

Northern Leopard Frog

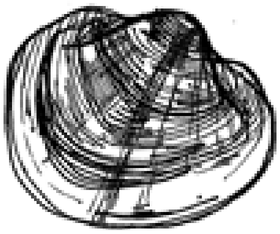


- *Appearance:* Green and brown with large spots on the back
- *Habitat:* Open fields near wetlands; in winter – bottom of lakes and ponds
- *Diet:* Insects, smaller frogs
- *Predators:* Snakes, raccoons, other frogs

Bald Eagle

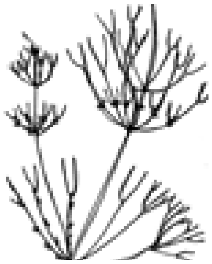
- *Appearance:* Mainly brown with white head and tail; large, hooked beak
- *Habitat:* Virtually any wetland area
- *Diet:* Mostly fish and birds
- *Predators:* None, top predators

Pocketbook Mussel



- *Appearance:* Green or dark brown outer shell, white inner shell
- *Habitat:* Rivers and streams with slow-flowing water
- *Diet:* Algae and microscopic bacteria
- *Predators:* Muskrats, otters, raccoons, ducks, fish

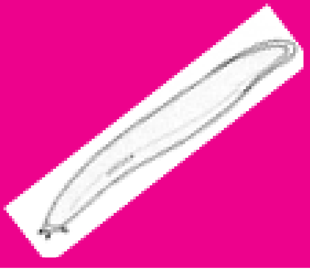
Algae



- *Appearance:* Green or yellow; long, thin, hair-like strands; forms a mat on the surface of the water
- *Habitat:* Freshwater and saltwater environments
- *Diet:* Makes sugar using energy from the sun (photosynthesis)
- *Predators:* Microorganisms, micro invertebrates, insect larva

Leech

(Replace with raccoon?)



- *Appearance:* Worm-like body with one sucker at each end; brownish in color
- *Habitat:* Any aquatic environment, but mostly freshwater
- *Diet:* Vertebrate and invertebrate blood
- *Predators:* Fish, turtles, crayfish, water birds

LESSON 3

Name________________________________ Date___________ Period _____

Lesson 3 - Image Credits

Images (drawn by Alaina Szostkowski except where noted below):

- Loon: http://digitalmedia.fws.gov/cdm/singleitem/collection/natdiglib/id/2206/rec/6
- Bald Eagle: http://digitalmedia.fws.gov/cdm/singleitem/collection/natdiglib/id/4314/rec/11
- Leech: https://commons.wikimedia.org/wiki/File:Eptatretus_cirrhatus_%28New_Zealand_hagfish%29.gif
- Crayfish: https://commons.wikimedia.org/wiki/File:Crayfish_(PSF)_cleaned.png
- Sago Pondweed: USDA, NRCS (2016). The Plants Database, Greensboro, NC: National Plant (plants.usda.gov/java/largeImage?imageID=pope6_001_avd.tif).

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LESSON 4 Loons Like Lakes

Lesson Objectives
The students will be able to:
- Differentiate between abiotic and biotic factors in an ecosystem
- Use spatial representations such as maps, graphs, and aerial photographs to assist them in making a decision on suitable nesting lake
- Use evidence from problem scoping to generate multiple initial ideas for selecting a lake
- Evaluate the alignment between the lake they propose and the problem.
- Communicate their solution using evidence-based reasoning
- Justify why the lake they have selected is appropriate using mathematics/science concepts
- *For a complete list of the Objectives see the Overview*

Time Required
Three 54-minute class periods

Materials
- **Per Class:** none
- **Per group:** none
- **Per Student:** 1 Pad of sticky notes, 1 Sheet of graph paper, Engineering notebook, Engineering slider with paper clip, Different colored pens/Pencils

Standards Addressed
- Next Generation Science Standards: MS-ETS 1-2, MS-ESS 3-3, MS-LS 2-5
- Common Core State Standards – Mathematics: 7.RP.A.2

Key Terms
biotic, abiotic, nesting platforms, water clarity

Lesson Summary
Students will learn about biotic and abiotic factors in an ecosystem. They will then choose a suitable metro area lake for a loon platform by using their knowledge of what loons look for in a nesting lake and assessing the abiotic and biotic factors of several different metro area lakes.

Background
Teacher Background
In this lesson, students continue to research loon habitats. They use evidence-based reasoning to justify their choice for a lake in which their platform should be placed. This justification is based on data about water clarity, size, human activity, and fish species present in six lakes in the Minneapolis-St. Paul metropolitan area. The design decision students make thus incorporates the needs of the end user.

Loons prefer to nest in lakes that have certain characteristics. For example, loons like lakes that have at least 3 m of underwater visibility so that they can see their prey. They favor fish that have erratic swimming patterns (such as Yellow Perch and Bluegill) because they are easier to catch than fish that swim in a straight line. Although they feed on multiple lakes, loons tend to return to the same lake every year to make a nest. In fact, they are more loyal to their territory than to their mates. Loons typically nest on lakes that are 20ha (49 acres), although they occasionally nest on lakes as small as 6ha (14 acres). They prefer lakes with bays and islands. A single breeding pair is supported on a lake smaller than 80ha (198 acres). Loons require a long distance in order to take off in flight, so they need a lot of space to live. Larger lakes can support multiple pairs of loons. Loons like as little disturbance as possible, and may abandon their nests if human activity becomes too intense.

> **Note:** The following video clip shows a loon taking flight, and can help illustrate why loons need larger lakes. It is available as of May, 2016 at: http://www.youtube.com/watch?v=MXdihx70H1g

Before the Activity
- Print and copy the following worksheets (1 per student) I made changes. Check this.
  - *4.a. Loons Like Lakes*
  - *4.c. Lake Data Collection Table*
  - *4.d. Data Chart from County Lakes (never mentioned in lesson).*
  - *4.e. Evidence-Based Reasoing Graphic: Lakes*
- Obtain enough graph paper for each student
- Prepare 6 Lake Stations, one for each lake:
  - Print 1-4 copies of the *4.b. Water Clarity/Time Data Table* for each lake
  - Print 1-4 copies of the photographs of each lake (*4.g.* images) (why 1-4?)
  - Place the information about each lake at that lake's station.

Classroom Instruction
Introduction
1. **Identify where we are in the engineering design process.** Begin class by asking students to use the *Engineering Design Process Slider* to show

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where they think they are in the engineering process of design.

2. **Review the design challenge.** Explain that today students will be completing part of the challenge by selecting a lake that would be appropriate for placing the platforms they create.
3. **Review biotic and abiotic.** Discuss these terms with the class and ask students to consider how these terms apply to the concept of an ecosystem. Call on volunteers to identify 1-2 biotic and abiotic factors in the loon's environment. Guide students to consider water as an important abiotic factor influencing the loon population on Minnesota lakes.

Activity

1. **Complete the *4.a. Loons Like Lakes* worksheet.** Distribute the worksheet and ask students to complete it. Encourage them to use any work from previous lessons (e.g., the *1.d. Memorandum* from Lesson 1 and the *2.a. All About Loons! Scavenger Hunt* worksheet from Lesson 2) to answer the questions.
2. **Organize class for the Graphing and Station Rotation activity.** Split the class into six groups (A, B, C, D, E, and F). Tell students that they will examine six different lake environments (one lake per letter). They will consider both biotic and abiotic factors that influence whether loons select that location to build a nest. Send each group to their assigned station.

Graphing and Station Rotation activity:
Part 1: Student Create Graphs of an Assigned Lake (1st station rotation)

3. **Direct students to examine the water clarity data table for that lake.** Once student teams are at their station, **ask**: *What does this data table show? Why is it important to compare water clarity in the different lakes?*
4. **Ask each group to create a line graph.** Guide each group to record the observed trend in water clarity over time. Predict a possible data point for the year 2016 and record. Have each team leave their graph at the station for the other groups to examine.

Part 2: Students Collect Data on All Lakes (Other five stations)

5. **Continue the rotations through the stations.** Distribute the *4.c. Lake Data Collection Table.* Guide students to rotate through the other five stations to collect data on the other lakes.
6. **Facilitate small group discussions about advantages and disadvantages of the different lakes.** Use the questions below to guide the discussion. (How do we do "small group"? Have groups meet up with other groups? This needs clarification.)
   - *Which lake had the highest clarity?*
   - *Which lake is the largest?*
   - *Which lake has the least human activity?*
   - *Which lake appears have the largest population of fish that loons prefer?*
   - *Which lake has the highest number of predators for the Common Loon?*
   - *Rank the lakes in order from your first to last choice for a platform.*
   - *Describe the reasons for your ranking using at least three complete sentences.*

Assessments

Pre-Activity Assessment
Prior to activity, check for student understanding of living vs. non-living.

Activity Embedded Assessment
Check students' progress as they analyze lake data and differentiate between biotic and abiotic components in an ecosystem.

Post-Activity Assessment
Teacher listens as students justify the lake choice with evidence from data.

DUPLICATION MASTERS

- 4.a. Loons Like Lakes
- 4.c. Lake Data Collection Table
- 4.d. Data Chart from County Lakes (Never mentioned in lesson).
- 4.e. Evidence-Based Reasoning Graphic: Lakes

EDUCATOR RESOURCES

- 4.b. Water Clarity/Time Data from DNR
- 4.f. Evidence-Based Reasoning Graphic Poster
- 4.g. Lake Photographs

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Loons Like Lakes

Day 2
Part 3: Presenting "Lake" choice to the class

7. **Students work to choose a lake.** Distribute the *4.e. Evidence-Based Reasoning Graphic: Lakes.* Tell students that their next job is to put all their data together and pick a lake. Remind students to use the data from each station to justify their choice for their nesting platform. Ask each team to complete their *4.e. Evidence-Based Reasoning Graphic: Lakes* once they have reached consensus on a suitable lake. Use the *4.f. Evidence-Based Reasoning Graphic Poster* to help students understand how to fill out the EBR graphic.
8. **Have each group share their reasoning/justification in a whole class discussion.**

    Note: Each group will use data on the following factors: Water clarity, lake area, human activity, and top fish species from the six Washington and Ramsey area lakes to decide on a suitable/preferred lake for their nesting platform.

Closure

1. **Revisit the Post-it T-Chart created in Lesson 1.** Students should add or move post-its as needed.
2. **Ask students to answer the following prompts in their engineering notebooks:**
    - *What data sources most influenced your choice for a lake?*
    - *How did your group work come to an agreement on the decision you made?*

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Loons Like Lakes

LESSON 4

LESSON 4

Name________________________________ Date___________ Period _____

4.a. Loons Like Lakes

1. Define:
   Abiotic Factors-

   Biotic Factors-

2. What do loons look for in a lake? List at least 5 items (fish type, size, etc.) that loons prefer in nesting lakes. Be specific!

   1. ____
   2. ____
   3. ____
   4. ____
   5. ____

3. Put an X next to items from your list that are biotic.
4. Put a check mark (✓) next to items from your list that are abiotic.
5. Rank the following factors from most important to least important for loons:
   Lake Size, Human Activity, Fish Species, Water Clarity

______________ ______________ ______________ ______________
Most Important Least Important

6. Do you think any nearby lakes could be a good place to put a loon nesting platform? Why or why not? Please explain.

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4.b. Water Clarity/Time Data

Washington and Ramsey County Area Lakes

Directions: Cut out the following six data tables and distribute one table per lake station.

A. Lake Elmo	
Year	**Water Clarity (m)**
1975	1.01
1985	2.14
1990	3.89
1995	3.34
2000	3.67
2005	4.1
2008	4.39

B. Lake Phalen	
Year	**Water Clarity (m)**
1975	1.14
1985	1.69
1990	1.21
1995	0.84
2000	1.56
2005	1.67
2008	2.67

C. Tanners Lake	
Year	**Water Clarity (m)**
1975	1.71
1985	2.48
1990	2.94
1995	3.68
2000	2.36
2005	2.95
2008	2.54

D. White Bear	
Year	**Water Clarity (m)**
1975	0.78
1985	1.28
1990	1.32
1995	1.26
2000	1.46
2005	1.73
2008	2.34

E. Keller Lake	
Year	**Water Clarity (m)**
1975	1.8
1985	2.5
1990	2.97
1995	3.78
2000	2.46
2005	2.85
2008	2.64

F. Lake Jane	
Year	**Water Clarity (m)**
1975	0.78
1985	1.5
1990	1.42
1995	1.3
2000	1.5
2005	1.83
2008	2.74

LESSON 4

Name________________________________ Date____________ Period _____

4.c. Lake Data Collection Table

Directions: As you rotate around each station, use information from the graphs made by your peers to fill in the chart. Make sure to include the appropriate data for the graph you made.

Station Letter/ Lake	Highest water clarity point on graph	Lowest water clarity point on graph	Approximate data point for 2016	Trend Observed
A. Elmo				
B. Phalen				
C. Tanners				
D. White Bear				
E. Keller				
F. Jane				

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LESSON 4

Name______________________________ Date__________ Period _____

4.d. Data Chart from County Lakes

Directions: Use the chart of data from Ramsey and Washington County area lakes (below) and the aerial photographs of each lake at each station to help you choose the best lake for your loon nesting platform. This chart will provide you with additional data you can combine with what you learned about water clarity. You are welcome to add additional observations.

Data Chart from Selected Washington and Ramsey County Lakes

Lake	Lake Area (acres)	Human Activity on Lake (High, Medium, or Low)	Top Fish Species in Lake and Number Sampled	Two Additional Observations from Lake Pictures and Maps
A. Elmo	281.21	High	Bluegill: 663 Tullibee: 52 Northern Pike: 32 Walleye: 15	
B. Phalen	197.68	High	Bluegill: 644 Yellow Perch: 38 Northern Pike: 16 Pumpkinseed: 14	
C. Tanners	74.39	Medium	Bluegill: 114 Pumpkinseed: 34 Yellow Bullhead: 19 Northern Pike: 15	
D. White Bear	2427.66	High	Bluegill: 721 Hybrid Sunfish: 122 Yellow Perch: 107 Northern Pike: 58	
E. Keller	72	High	Bluegill: 217 Black Crappie: 54 Pumpkinseed: 8 Yellow Perch: 6	
F. Jane	152.75	Medium	Bluegill: 399 Northern Pike: 93 Yellow Bullhead: 44 Pumpkinseed: 41	

CUT OUT THE TABLE AND GLUE IT IN YOUR NOTEBOOK.

LESSON 4

Name________________________________ Date___________ Period _____

4.e. Evidence-Based Reasoning Graphic: Lakes

Problem with Criteria & Constraints (What do you need to worry about?)	
Problem: Selecting a suitable site/lake for loon nesting platforms **Criteria:** **Constraints:**	
Simplifying Assumptions (What do you not need to worry about?)	
Plan (Design Idea)	**Data/Evidence** (Facts)
What lake would you choose?	List the evidence you found from analyzing the lake data.
Explanation, Justification, Reasoning (Why do you think this will work?)	
Why does the evidence you chose support your claim that your lake is the best solution.	

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4.f. Evidence-Based Reasoning Graphic

Poster with Explanation

Problem with Criteria & Constraints (What do you need to worry about?)

Problem: the engineering problem the client asked you to solve

Criteria: the requirements, or goals, of the designed solutions

Constraints: things that limit design possibilities

Simplifying Assumptions (What do you not need to worry about?)

Ways to make a complex problem simpler

Plan (Design Idea)	**Data/Evidence** (Facts)
• Description of the design • Drawings of the design, different views • Dimensions (sizes) • Label materials in design (show where they are used) • Interesting features	Observations and data that show why you think your design will work Examples: • Data science experiements • Total cost of design

Explanation, Justification, Reasoning (Why do you think this will work?)

Complete sentences that state why you think your design will be successful. These sentences should refer to the problem, criteria, constraints, idea, and data/evidence.

4.g. Lake Photographs

Lake Phalen

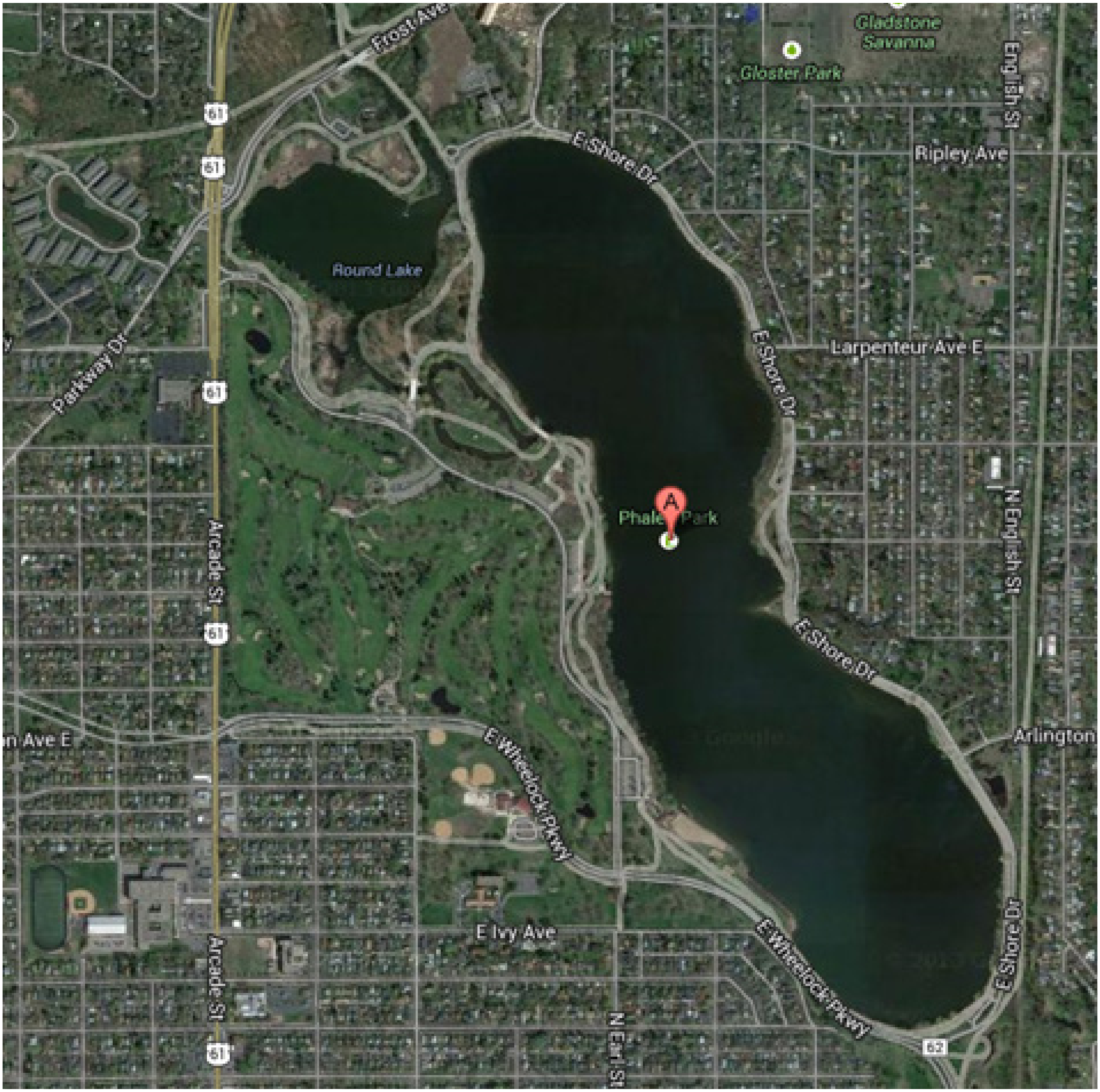

Image taken from Google Earth

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4.g. Lake Photographs

Keller Lake

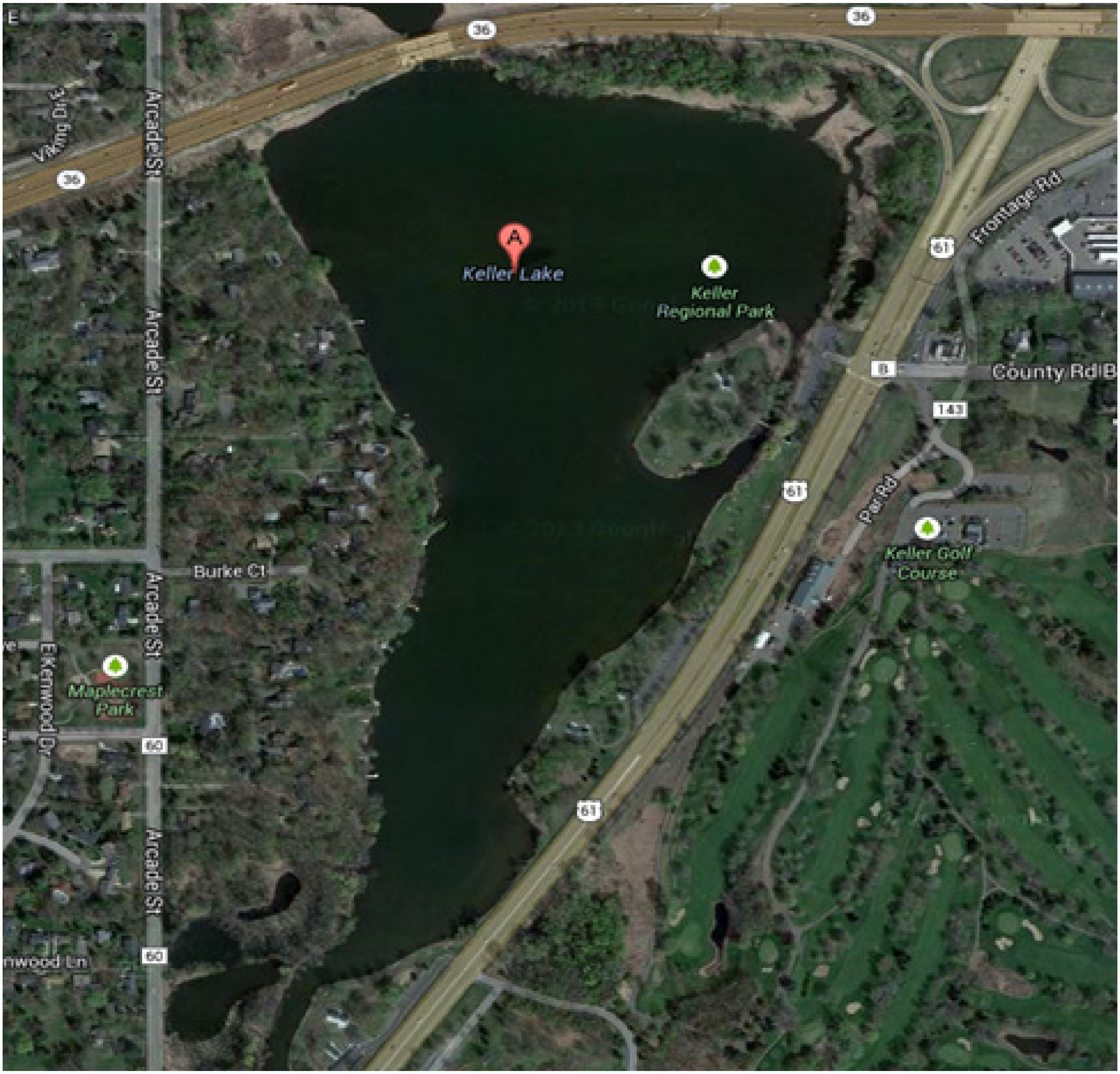

Image taken from Google Earth

4.g. Lake Photographs

Tanners Lake

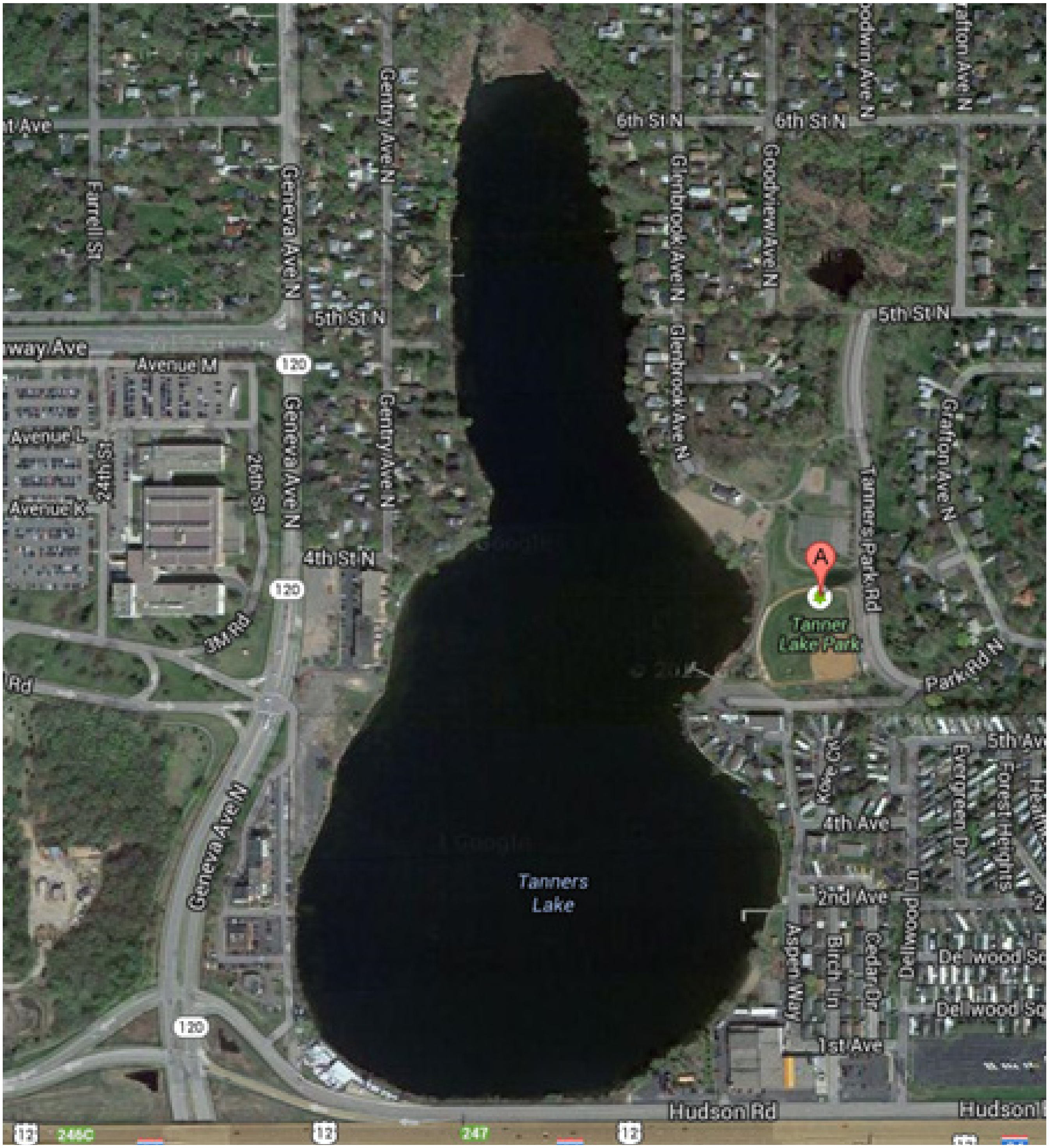

Image taken from Google Earth

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4.g. Lake Photographs

Lake Jane

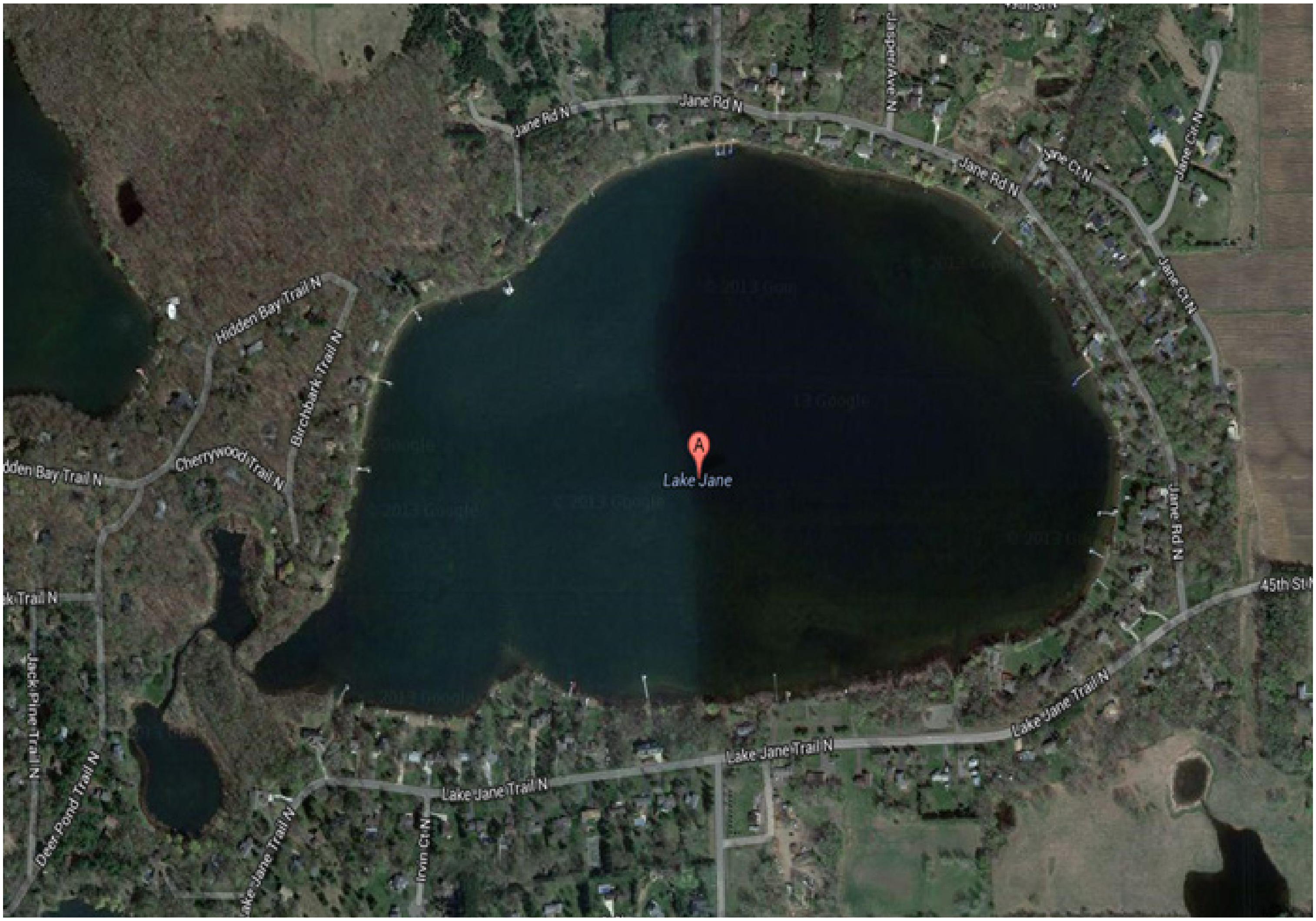

Image taken from Google Earth

4.g. Lake Photographs

White Bear Lake

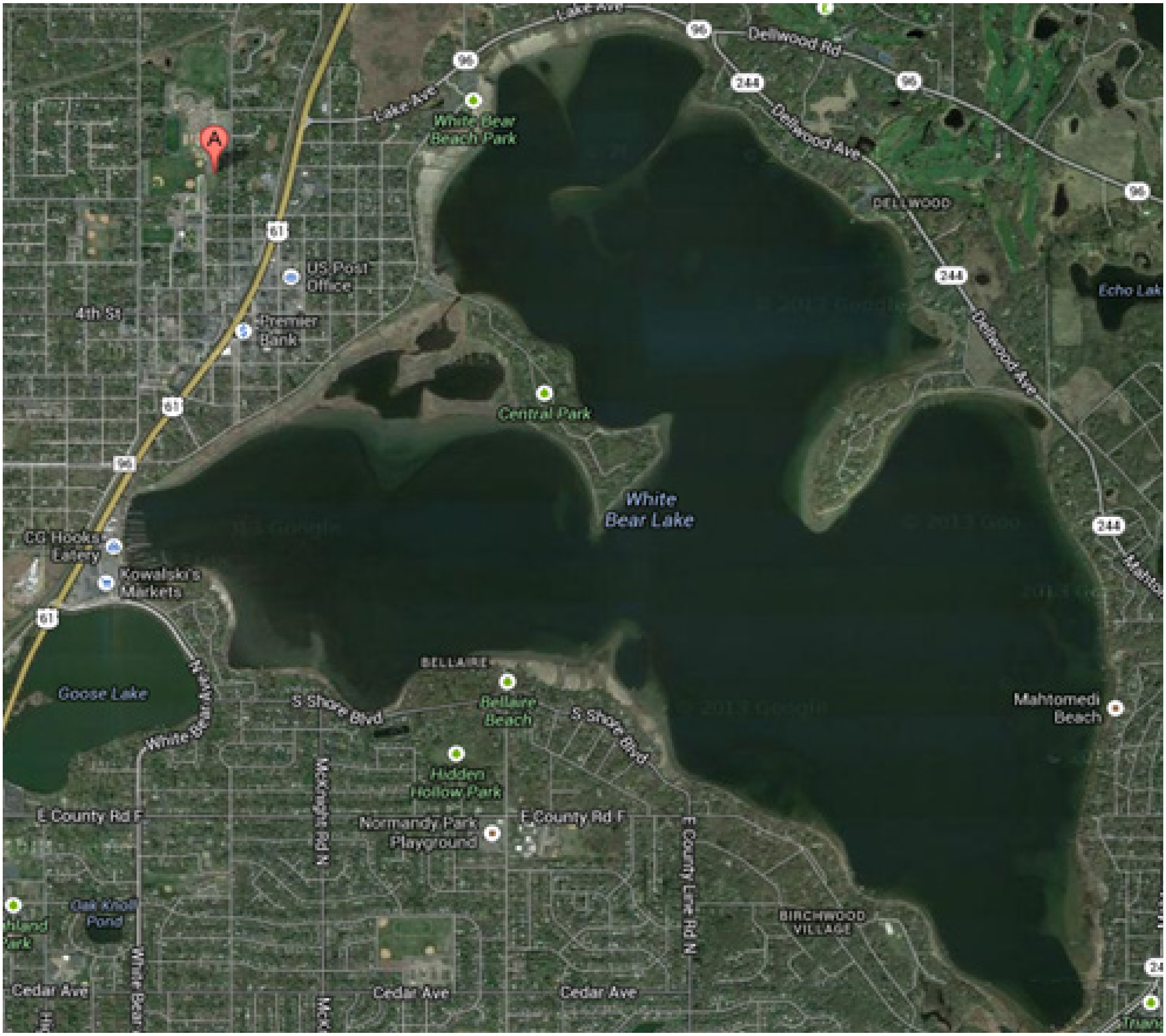

Image taken from Google Earth

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Lake Elmo

Image taken from Google Earth

LESSON 5

Nest Sweet Nest

Lesson Objectives
The students will be able to:
- Match common birds and their nests
- Compare different types of bird nests
- Gather additional evidence (i.e., regarding applied science/mathematics concepts) to help identify the needs of the loons (end user)
- Calculate the area of a circle and a square
- Use percentages and proportionality to scale down the size of their nest platform

Time Required
One 54-minute class period

Materials
- **Per Class:** none
- **Per Group:** 1 ruler, 1 compass (for drawing)
- **Per Student:** 1 Sheet of construction paper, 1 Pair of scissors, 1 Scientific calculator, Engineering notebook, Engineering slider with paper clip, Different colored pens/pencils

Standards Addressed
- Common Core State Standards – Mathematics: 7. G.B.4, 6.RP.A.3, 7.RP.A.2

Key Terms
proportion, area, diameter, percentage, prototype, template

Lesson Summary
Students will match pictures of common birds to pictures of their nests. Next, they will calculate the area of a life-size loon's nest. They will then scale down the actual size to 25% to ensure their prototype fits in the "lake".

Background
Teacher Background
This lesson represents the transition from the research to the planning phase of the engineering design process. The students begin the lesson by matching common birds to their nests. The purpose of this activity is to activate prior knowledge and to help students make connections between bird size and nest size. The data table on the following page (*Bird Mass and Nest Size*) includes sample body mass and nest size data for eight common birds. This information may be displayed to the class once the nests and birds have been matched, or copied and distributed to students. The data collected for this table can be found at The Cornell Lab of Ornithology, available as of June, 2016 from http://www.birds.cornell.edu/Page.aspx?pid=1478.

Students calculate the area of a loon's nest to get a sense of the size of the final product and the necessary scale of their prototype. Students will be asked to create platform prototypes that are 25% the size of an actual loon's nest. In doing so, they must use proportional and algebraic reasoning to accurately determine the relationship between nest dimensions (diameter) and area. In order to be successful in this activity, students should have prior knowledge of area formulas and be able calculate square roots and percentages. Students may need additional guidance to find dimensions of the scaled-down platform. You may scaffold this by drawing students' attention to the ratio between the original and new width of a scaled square. Guide students to the observation that while the area is ¼ of the original, the diameter/width of the platform is ½ of the original. Provide an example of the relevant proportions or solve a problem together. For example, students could add values to the table below:

Original Diameter of Circle	Area of circle	25% Area	New diameter (multiply by 2 once you solve for r OR multiply your original diameter by .5)
8 cm	16π cm^2	4π cm^2	4 cm
10 cm	25π cm^2	6.25π cm^2	5 cm
12 cm		9π cm^2	

Original Width of Square	Area of square	25% Area	New Width (square root of area OR multiply original width by .5)
8 cm	64 cm^2	16 cm^2	4 cm
10 cm	100 cm^2	25 cm^2	5 cm
12 cm		36 cm^2	

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Nest Sweet Nest

Before the Activity

- Obtain pictures of the 8 birds listed in the chart and their 8 nests. Students will be matching the nest to the bird, so these need to be separate pictures. The birds are listed below:
  - American Crow
  - American Goldfinch
  - American Robin
  - Bald Eagle
  - Common Loon
  - Great Blue Heron
  - Northern Cardinal
  - Ruby-Throated Hummingbird
- Print and copy student worksheet: *5.a. Your Best Nest Platform Design: Choosing Shape and Dimensions* (1 per student)
- Cut out a circular template that is the actual size of a loon nest (diameter ≈ 56 cm, area ≈ 2463 cm^2) **(Your instructions are unclear as to what you want here.)**
- Display or copy the following information to be used in a class discussion following the nest-matching activity.

Bird Mass and Nest Size

Bird	Body Mass	Nest width
American Crow	316 - 620 g	15.2 – 48.3 cm (6-19 in.)
American Goldfinch	11 - 20 g	7.6 cm (3 in.)
American Robin	77 - 85 g	15.2 – 20.3 cm (6-8 in.)
Bald Eagle	3000 - 6,300 g	152.4 - 182.9 cm (5-6 ft.)
Common Loon	2500 - 6,100 g	55.9cm (22 in.)
Great Blue Heron	2100 - 2,500g	50.8 – 121.9 cm (20 in – 4 ft.)
Northern Cardinal	42 – 48 g	10.2 cm (4 in.)
Ruby-throated Hummingbird	2 - 6 g	5.1 cm (2 in.)

**Data collected from The Cornell Lab of Ornithology found at http://www.birds.cornell.edu/Page.aspx?pid=1478*

Classroom Instruction

Introduction

1. **Review where we are in engineering design process using the *Engineering Design Process Slider*.** Explain that today students will complete the research stage. Ask students to turn and talk to a partner,

Assessments

Pre-Activity Assessment
Bird and nest matching activity to assess prior knowledge on bird nesting platforms.

Activity Embedded Assessment
Teacher checks student progress on area calculations as they are working on activity.

Post-Activity Assessment
Examine nest design templates to assess how well students' geometric shape chosen for their designs fits within the 25% scale of its actual size.

DUPLICATION MASTERS

- 5.a. Your Best Nest Platform Design: Choosing Shape and Dimensions

EDUCATOR RESOURCES

- none

and identify and explain what they think will come next (e.g., planning a design that can be built into a prototype or model that is tested).

2. **Review what has been learned previously using the *T-Chart Poster* from Lesson 1.** Review what the students have learned and ask them if there is anything else they need to know before they can begin to plan a solution. Draw students' attention to a discussion about loon nests.
3. **Introduce today's lesson.** Tell students that today they are going to learn about different types of nests. Ask them why they need to think about nests and loons' needs before they try to solve the engineering challenge.

Activity

1. **Access prior knowledge about nests.** Have students identify and record what they know about nests in their engineering notebook.
2. **Match birds and nests.** Show students 5-8 pictures of birds and 5-8 pictures of nests that are not currently matched. Ask students to write down what they think the correct matches are in their engineering notebooks. Once students have recorded their guesses, discuss the correct answers as a class. As needed, share the Bird Mass/ Nest Size data chart found in the teacher background section.
3. **Revisit the nest pictures.** Ask students to identify similarities and differences between the nests. Have them explain why each bird might prefer one type of nest over another.
   Optional: Guide students to find the mean body mass and nest width for each board and create a scatter plot of the data then estimate the trend.
4. **Introduce concept of a scale model.** Show a pre-cut template that is the area of an actual loon's nest. Tell students that for their prototypes, they will be making a platform that is 25% of the area of a real nest. Explain that engineers often test scale models before making their final design decision. **Ask** students to answer the following question with a neighbor: *Why do you think we are making a scaled-down version of our platform?* (It will use fewer materials, take less time to construct, easier to transport and assemble, etc.)
   Note: It may also be helpful to show them the bin they will be using to test their prototype, as it will not fit a full-sized platform.
5. **Calculate prototype area.** Distribute *5.a. Your Best Nest Platform Design: Choosing Shape and Dimensions* worksheet. Direct students to complete the worksheet. Tell them to calculate the area of a life-size nesting platform based on the dimensions provided for a circle and a square. Direct them to find 25% of this area (multiply the area by 0.25) to determine the area for their prototype.
6. **Choose platform shape.** Based on this information, have students choose whether they want to build a circle or square platform. Ask them to work independently to calculate the dimensions of their prototype. Encourage students to use a range of strategies to find the answer (guess and check, proportional reasoning, solving for the unknown, drawing a picture).
   Note: It is more challenging to perform the necessary calculations with a circle platform. You may use these two choices as an opportunity to differentiate instruction. **See Teacher Background section** for more potential scaffolding ideas.

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7. **Make platform template.** Once students have calculated the dimensions of their platform prototype, ask them to use appropriate tools to measure and cut a square or circle template out of construction paper. Tell them that the template will be used during the building process to make sure that platform remains the appropriate size.

Closure

1. **Justify their design choice.** Revisit the *5.a. Choosing Shape and Dimension* student worksheet. Ask students to justify why they choose that geometric shape (circle or square) for their template. Ask them to record their answers in their engineering notebook.
2. **Complete notebook prompt.** Provide them the following prompt to answer in their engineering notebook.
    - *What factors do you need to consider when designing a nesting platform that will appeal to a loon?*

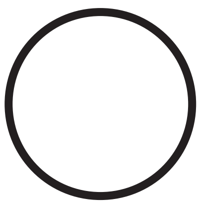
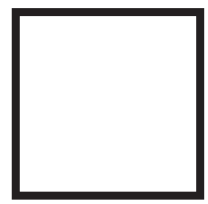
LESSON 5

Name________________________________ Date___________ Period _____

5.a. Your Best Nest Platform Design

Choosing Shape and Dimensions

Your nesting platform design needs to be 25% of the area of an actual loon nest.

New Circle Dimensions	New Square Dimensions
1. Complete the table below to find the diameter and radius of the scaled-down circle. Use this picture of a circle to help you visualize it. 	2. Complete the table below to find the width of the scaled-down circle. Use this picture of a square to help you visualize it. 

Shape	Actual Loon Nest Dimensions	Area Formula	Area of Actual Loon Nest (cm^2)	25% of Actual Loon Nest Area (cm^2)	New Dimensions for Nest
Circle	d = 56 cm r = ______				d = ______ r = ______
Square	w = 56 cm				w = ______

3. Will your platform be a circle or a square? ______________________
Explain your reasoning below.

4. How did you determine the relationship between the area and dimensions of your scaled-down platform?

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LESSON 6 If You Build It, They Will Come

Lesson Objectives
The students will be able to:
- Use evidence from problem scoping to generate multiple initial ideas for the design of a nesting platform
- Select a design solution through systematic evaluation of various solutions based on the problem
- Build a prototype of their nesting platform
- Test their nesting platform
- Analyze test results of their nesting platform
- Evaluate the alignment between their nesting platform and the problem

Time Required
Two to three 54-minute class periods

Materials
- See Overview at the beginning of unit

Standards Addressed
- Next Generation Science Standards: MS-ETS1-2, MS-ETS1-2, MS-ETS1-3, MS-ETS1-4

Key Terms
buoyancy, constraints, prototype

Lesson Summary
Students will be re-introduced to the engineering design challenge. They will be provided with a complete set of constraints (rubric) for the challenge and are given time to start planning. After planning, students will build their loon nesting platform design and test their prototype.

Background
Teacher Background

During this lesson, students will be using what they have learned about nest size and shape to construct loon nesting platform prototypes. In recent years, humans have encroached on the natural loon nesting environment through the process of lake shoreline development. This has caused many loons to relocate either to different lakes or to different states to be able to have a protected nest. As a result, humans have started to build artificial platforms on which loons are able to build and protect their nests.

According to the Sigurd Olson Environmental Institute in Wisconsin, artificial loon nesting platforms (ANPs) have been built in Midwest lakes since the 1970s. Research conducted on their effectiveness determined that ANPs can be a helpful management strategy on lakes that already possess other preferable conditions for loon nesting but have been affected by shoreline development. However, ANPs can sometimes result in increased predation because of their enhanced visibility. Preservation of traditional nesting locations better ensures long-term population stability.

Most platforms float close to the shoreline of a lake in 5-8 feet of water. They may need maintenance between each nesting season, but many platforms are made of unnatural materials that will not disintegrate or break down very easily. Early ANP designs did not have any protection from aerial predators such as eagles, but now platforms are constructed with some sort of protection in mind. Newer designs may also include a ramp or some kind of access point for chicks to get on and off of the platform once they have hatched, as well as a reflector to make the ANP visible to night boat traffic.

More information, as well as an ANP design, is available from the following page as of May, 2016: http://maineaudubon.org/wp-content/uploads/2011/10/LoonWatch-foam-raft.pdf

Before the Activity
- Print and copy 6.a. *Your Best Nest Platform Design: Individual Plan* sheet (multiple per student)
- Print and copy 6.b. *Evidence-Based Reasoning Graphic* (1 per student)
- Print and copy 6.c. *Your Best Nest Platform Design: Group Plan* sheet (2-sided, 1 per group)
- Print and copy 6.d. *Your Best Nest Platform: Scoring Guide* (1-2 per group)
- Gather the necessary materials for engineering challenge
- Set up at least two testing stations. Each station should be identical with identical materials: bin, water level marker, stir stick, and timer/stopwatch. Fill water bins with water, up to the marker.

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LESSON 6

If You Build It, They Will Come

Classroom Instruction

Introduction

1. **Review the challenge and where they are in the engineering design process.** Briefly review what the client is asking students to accomplish. Ask students to identify where they think they are in the engineering process of design using the *Engineering Design Process Slider*. Have a few students justify their answer.
2. **Review what has been learned previously using the *T-Chart Poster* from Lesson 1.** Use the poster to facilitate a brief discussion in which students recall what they know about the problem and what they have learned so far to help them understand and solve it.
3. **Identify next steps.** Ask students to share what they believe their next step should be in the process and have them explain their thinking.

Activity

Day 1

Problem Scoping

1. **Introduce the day's activities. Say:** *Today we will plan, build and test our prototypes*. Ask students to explain what is meant by the word prototype and why an engineer might build one.
2. **Ask for additional questions and provide information as requested.** Ask the class if there is any additional information they need or questions they have before they begin planning. *Encourage them to ask questions, rather than supplying them with all of the information at once.* For example, students may want to know what supplies they will have to build their prototype. When they do, hand out the *6.a. Your Best Nest Platform Design: Individual Plan* worksheet to each student. This worksheet contains a materials list. Students may also ask questions about cost, time, tests to complete, and how their platforms will be evaluated. When they do, display the *6.d. Your Best Nest Platform: Scoring Guide* rubric (it will be distributed later in the lesson).

Planning

3. **Complete individual plans.** Encourage students to make at least three individual designs for the loon nesting platform. Ask them to record their work on the *6.a. Your Best Nest Platform Design: Individual Plan* worksheet.
4. **Provide evidence for their design decisions.** Ask students to complete a *6.b. Evidence-Based Reasoning Graphic* for each idea. [Students may hand draw the EBR Graphic or cut and paste the graphic into their notebook.] The 4.f. EBR Graphic Poster can be used to help scaffold this process.
5. **Share ideas in teams.** Once each student has completed an individual plan (6.a.) and an *EBR Graphic* (6.b.) for each idea, organize the class into engineering teams. Encourage each team member to share and explain their design to the rest of the group.
6. **Decide on a team design.** When each group member has shared, distribute copies of the *6.c. Your Best Nest Platform Design: Group Plan* worksheet. Explain to students that their next task as a team is to agree

Assessments

Pre-Activity Assessment
None

Activity Embedded Assessment
Informally monitor each group's progress through the engineering design process by asking questions during the lesson.

Use the planning worksheets and the *EBR Idea Graphic: Loon Platform*.

While students build prototypes and also during testing, assess student team's progress with Teacher Observation Protocol

Prior to testing, students complete Engineering Notebook Test questions

Post-Activity Assessment
Review reflection prompts in students' engineering notebooks.

DUPLICATION MASTERS

- 6.a. Your Best Nest Platform Design: Individual Plan
- 6.b. Evidence-Based Reasoning Graphic
- 6.c. Your Best Nest Platform Design: Group Plan
- 6.d. Your Best Nest Platform: Final Scoring Guide

EDUCATOR RESOURCES

- 6.e. Teacher Observation Protocol: Try Lesson
- 6.f. Teacher Observation Protocol: Test Lesson

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on a design. Ask each student to answer the following questions in their engineering notebook as they share their ideas:
- *What are the pros and cons of each of your solutions?*
- *Which solution did your team choose and why?*

Note that groups are responsible for combining ideas from group members into their prototype design. Groups must complete group planning sheet and obtain permission before starting to assemble their prototype.

Day 2-3
Building and Testing Prototypes

7. **Scaffold cooperative learning strategies.** Have teams assign team roles. Potential roles can include:
   - **Team Manager:** This group member helps ensure that everyone gets a chance to contribute and that conversation remains respectful and inclusive. The manager keeps the group on time and on task.
   - **Materials Manager:** This group member keeps track of the group's materials and gets the supplies from the teacher.
   - **Accountant:** This group member keeps track of the money that was spent and the budget remaining.
   - **Building Manager:** This group member helps the group stay on task with the building of the loon platform and ensures that everyone has a job to do.
8. **Build their prototypes.** Direct students to collect supplies and build once they have permission. Remind them to use only the materials provided and that they need to keep track of the cost of the materials used.
9. **Assess student progress.** As students are building, walk around and assess student progress with the *6.e. Teacher Observation Protocol: Try Lesson.*
10. **Test their prototypes.** The two tests below can be completed sequentially and require a total of four minutes in the water bin per group. The directions for the tests may be placed at each testing station. If necessary, model for the whole class how to conduct the tests. When a group is ready to test their design, display the "loon" weight and place it on the nest.
    - **Buoyancy Test:** Ask students to place their nesting platforms containing the "loon" (weight) in the bins filled with water. They should start a timer to determine how long the platform floats.
    - **Wave Test:** After timing for two minutes, ask a group member to gently stir the water in the container to create waves. Have the student stir continually for an additional two minutes. If the prototype remains afloat and dry for the entire time, it has passed both tests.
11. **Assess student progress.** As students are testing, walk around and assess student progress with the *6.f. Teacher Observation Protocol: Test Lesson.*
12. **Calculate scores from tests.** Distribute the *6.d. Your Best Nest Platform: Scoring Guide*. Instruct students to calculate their score once all groups have tested their prototype.

Closure

1. **Reflect using notebook prompts.** Ask students to reflect on their design

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using the following engineering notebook prompts:

- *What have you learned about the performance of your solution from your test results?*
- *What changes will you make to your solution based on the results of your tests? Explain why you want to make those changes.*
- *What changes will you make to your solution based on the science and/or math you have learned? Explain why you want to make those changes.*
- *In what ways does your solution meet the criteria and constraints of the problem?*
- *In what ways does your solution not yet meet the criteria and constraints of the problem?*
- *Go back and look at how you described the problem right after talking with the client. How would you change your description of the problem not that you have planned, tried, and tested a solution? (Think about criteria, constraints, client need, and/or things you need to learn.)*

LESSON 6

Name________________________________ Date____________ Period _____

6.a. Your Best Nest Platform Design

Individual Plan

Materials List

Material	Cost
Cardboard	$4.00
Bubble Wrap	$2.00
Plastic Grid Sheet	$6.00
Wax Paper	$3.00
Foam Sheet Square	$4.00
Aluminum Foil	$3.00
1 Dixie Cup	$2.00
1 Ping Pong Ball	$1.00
1 Plastic Bottle	$2.00

Material	Cost
1 Playing Card	$1.00
3 Straws	$1.00
3 Pipe Cleaners	$1.00
3 Wooden Sticks	$1.00
Bag of Plastic Grass	$2.00/bag
Bag of Soil	$2.00/bag
Bag of Hay/Straw	$3.00/bag
Bag of Moss	$3.00/bag
Tape/Hot Glue	Free

Sketch of proposed design.

List of materials you want to use.

Why did you pick those materials?

Why did you choose that design?

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LESSON 6

Name________________________________ Date____________ Period ______

6.b. Evidence-Based Reasoning Graphic

Problem with Criteria & Constraints (What do you need to worry about?)	
Problem: **Criteria:** **Constraints:**	
Simplifying Assumptions (What do you not need to worry about?)	
Plan (Design Idea)	**Data/Evidence** (Facts)
Explanation, Justification, Reasoning (Why do you think this will work?)	

LESSON 6

Name________________________________ Date____________ Period _____

6.c. Your Best Nest Platform Design

Group Plan

Materials List

Material	Cost
Cardboard	$4.00
Bubble Wrap	$2.00
Plastic Grid Sheet	$6.00
Wax Paper	$3.00
Foam Sheet Square	$4.00
Aluminum Foil	$3.00
1 Dixie Cup	$2.00
1 Ping Pong Ball	$1.00
1 Plastic Bottle	$2.00

Material	Cost
1 Playing Card	$1.00
3 Straws	$1.00
3 Pipe Cleaners	$1.00
3 Wooden Sticks	$1.00
Bag of Plastic Grass	$2.00/bag
Bag of Soil	$2.00/bag
Bag of Hay/Straw	$3.00/bag
Bag of Moss	$3.00/bag
Tape/Hot Glue	Free

Sketch of proposed design with measurements.

List of materials you want to use.

Final Cost

____

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LESSON 6

Name______________________________ Date___________ Period _____

6.c. Your Best Nest Platform Design

Actual Budget

When you purchase an item, record the item and the amount purchased below to track the total cost of your project.

Name of Item	Cost per Item	Quantity	Total Cost of Individual Item
		Total Cost of All Items	

Daily Work Journal

Briefly record what you accomplished each day and what your next steps are for the next class period.

Date	Work Accomplished	Next Steps

LESSON 6

Name________________________________ Date___________ Period _____

6.d. Your Best Nest Platform Scoring Guide

Scoring/Criteria				Your Score
Buoyancy (Does it float when loon is added?)	0 No, it doesn't float	5 It floats for 1-2 minutes	10 Yes, it floats for more than 2 minutes	
Stability in waves	0 Tips over in waves or damaged beyond repair	5 Has little damage, partially tipped over in waves	10 Remains upright, no damage	
Privacy/ Protection	0 Loon is totally open and exposed to predators	8 Loon is partially protected from overhead predators	15 Loon is mostly protected from overhead predators	
Water Access	0 Platform does not allow adults or chicks to easily access to water	5 Platform allows adults or chicks to easily access to water but not both	10 Platform allows adults and chicks to easily access to water	
Cost	0 $50.00 or more	5 $20.01 to $49.99	10 $20.00 or less	

Total Score______________

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6.e. Teacher Observation Protocol: Try Lesson

Directions:
This is an observation assessment. The main purpose of this assessment is to observe evidence that student teams are working together to make their solution. In addition, this is opportunity to further assess that students are making design-decisions based on understanding the problem.

- **Part 1:** As you walk around to each team, please put a check by the behaviors you observe.
- **Part 2:** Interact with each team to assess their progress on the project. You may choose to ask some of the following questions or your own questions. You may also choose to add (or not) your own additional teaming-related assessment, as you deem appropriate. There is space for you to take notes of your observations.

Part 1: Behaviors

☐ All team members are on-task to make/try their solution.

☐ One or more team members are not on-task.

Notes:

☐ Team has made appropriate progress on their solution.

☐ Team is struggling to make their solution.

Notes:

☐ Team is making/made a solution directly related to problem.

☐ Team is making/made a something unrelated to problem.

Notes:

6.e. Teacher Observation Protocol: Try Lesson

Part 2: Question Prompts
Note: These questions can be used to further draw out and scaffold students' evidence-based reasoning. While the main purpose of these questions is to assess students' reasoning, it is also appropriate to interact with students/question for the purpose to support learning. Please note student responses below.

1. Can you tell me about your solution? What are you designing?

2. What were some of the other solution ideas you generated? How well did they address the problem?

3. How did you decide to move forward with this idea? What evidence do you have that your design will solve the problem for the client?

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6.f. Teacher Observation Protocol: Test Lesson

Directions:
This is an observation assessment. The main purpose of this assessment is to observe evidence that student teams are working together to make their solution. In addition, this is opportunity to further assess that students are making design-decisions based on understanding the problem.

- **Part 1:** As you walk around to each team, please put a check by the behaviors you observe.
- **Part 2:** Interact with each team to assess their progress on the project. You may choose to ask some of the following questions or your own questions. You may also choose to add (or not) your own additional teaming-related assessment, as you deem appropriate. There is space for you to take notes of your observations.

Part 1: Behaviors
Testing

☐ All team members are on-task to test solution.

☐ One or more team members are not on-task.

Notes:

☐ Team has made appropriate progress on testing and analysis.

☐ Team is struggling to test or analyze their solution.

Notes:

☐ Team has identified how to improve solution.

☐ Team is struggling to consider improved performance.

Notes:

6.f. Teacher Observation Protocol: Test Lesson

Part 2: Question Prompts
Note: These questions can be used to further draw out and scaffold students' evidence-based reasoning. While the main purpose of these questions is to assess students' reasoning, it is also appropriate to interact with students/question for the purpose to support learning. Please note student responses below.

4. What did you find out from testing?

5. How did you interpret the findings from your tests? What do you think the results mean?

6. How did you decide what could improve your solution's performance?

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LESSON 7 Redesign and Reporting

Lesson Objectives

The students will be able to:

- Apply evidence gathered through test analysis to improve the performance of chosen solution
- Select an improved design solution through systematic evaluation of various solutions based on the problem and evidence gathered
- Build improved prototype of their nesting platform
- Test their improved nesting platform
- Evaluate the alignment between their nesting platform and the problem
- Describe what they have learned through testing and evaluation process
- Communicate their design solution through use of evidence-based reasoning.
- Justify why their design solution is appropriate based on application of core science/mathematics concepts and information obtained in problem scoping

Time Required

Two to Three 54-minute class periods

Materials

- See Overview at the beginning of unit.

Standards Addressed

- Next Generation Science Standards: MS-ETS1-2, MS-ETS1-3, MS-ETS1-4

Key Terms

redesign, rubric

Lesson Summary

Student groups will redesign and rebuild their nesting platforms, and then score their revised design using the Redesign scoring guide. To share their designs, they will give short presentations to their peers. Finally, they will synthesize their learning in a persuasive letter to the client.

Background

Teacher Background

Redesign is a vital piece in the engineering design process. It is important for students to refine their design, just as a real engineer would do.

Before the Activity

- Make copies of *7.a. Your Best Nest Platform Redesign, 7.b. Your Best Nest Platform Scoring Guide,* and *7.c. Evidence-Based Reasoning Graphic* worksheets for each group.
- Replenish building supplies as necessary

Classroom Instruction

Introduction

1. **Review the challenge and where they are in the engineering design process.** Ask students to show where they think they are in the design process using their *Engineering Design Process Slider*. Have a few students justify their answers with the class.
2. **Highlight redesign.** Show the *Engineering Process of Design Graphic* and discuss the importance of redesign. **Say:** *Redesign is an extremely important part of the engineering design cycle. Engineers continually refine their designs.*

Activity

1. **Plan the redesign.** Distribute the *7.a. Your Best Nest Platform Redesign* worksheet to each group. Allow groups time to discuss and make changes to their design.
2. **Build the redesign.** Once you have given permission, have teams build their redesiged platform.
3. **Assess student progress.** As students are building, walk around and assess student progress with the *7.d. Teacher Observation Protocol: Try Lesson.*
4. **Test the redesign.** Have students test and score their redesigned platform. Use the same procedure from the previous lesson. When a group is ready to test their design, provide them with a weight to add to their platform. This weight will serve as the "loon."
    - **Buoyancy Test:** Ask students to place their nesting platforms containing the "loon" (weight) in the bins filled with water. They should start a timer to determine how long the platform floats.
    - **Wave Test:** After timing for two minutes, ask a group member to gently stir the water in the container to create waves. Have the student stir continually for an additional two minutes. If the prototype remains afloat and dry for the entire time, it has passed both tests.
5. **Assess student progress.** As students are building, walk around and assess student progress with the *7.e. Teacher Observation Protocol:*

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Redesign.

6. **Calculate scores from tests.** Distribute the *7.b. Your Best Nest Platform: Scoring Guide*. Instruct students to calculate their score once all groups have tested their prototype.
7. **Present their solutions.** Each group should give a brief presentation on their design process. As groups present, ask questions to encourage students to share the reasoning behind their decisions.
   - *Tell us about your design.*
   - *What went well? Why?*
   - *What didn't go well? Why?*
   - *What would you change if you had a chance to do it again?*

   After all groups have presented, share with the students that engineers often work under design constraints. **Say:** *Unfortunately, we don't have time to do many iterations in the world. However, we can share what we've learned with our client.*
8. **Write letter to the client.** Tell students that they need to write a persuasive letter to the client about their proposed solution to the problem. Use the *Evidence-Based Reasoning* explanation poster to review what it means to justify a design with evidence. Instruct students to use these pieces (i.e., solution, data/evidence, explanation/reasoning/justification) in their communication to the client. Provide a copy of *7.c. Evidence-Based Reasoning Graphic* to be used if they want or need extra scaffolding in this process. These letters must persuade the client that the solution meets their criteria, as well as the needs of the end user. Display criteria for the client letter to the class.
   The letter must:
   - Must explain how your solutions may impact the lake ecosystem.
   - Show the client that you understand the problem, and provide a description of how your solution will address it.
     - Include the lake you chose as well as your prototype design.
   - Use data to support your recommendations. Include figures and skecthes. Include evidence and explanations for your design decisions.
   - Include a description of the features that made your platform successful and how you know that it worked (remember, you're trying to convince the client to use your prototype!)
   - Be sure to explain aspects of your prototype that still require refinement or improvement and why these need to be addressed.
   - Be in a business letter format.
   - Be persuasive, organized, and free of grammatical errors.

   Provide students with approproate time to complete and share letters.

Unit Closure

1. **Reflect on the engineering design process.** Have the students reflect in their engineering notebooks about the entire unit both individually and in their team. Use the following prompts:
   A. Look back in your Engineering Notebook to see how you defined the problem throughout solving the problem. **How has your <u>understanding of the problem changed</u> during the design process?** Think in terms of client needs, criteria, constraints, and the science and mathematics needed to solve the problem.

Assessments

Pre-Activity Assessment
On Day 1, using the Engineering Design Process Slider, assess students' understanding of where they are in the engineering design process.

Activity Embedded Assessment
On Day 2, Monitor student presentations to ensure student responses are justified based on client criteria, end user needs, and relevant mathematical and scientific reasoning.

Post-Activity Assessment
After Day 3, assess students' recommendation letters to the client. The letters may also be assigned as homework. It may be graded on persuasiveness, inclusion of relevant data, and evidence from tests and research.

DUPLICATION MASTERS
- 7.a. Your Best Nest Platform Redesign
- 7.b. Your Best Nest Platform Scoring Guide
- 7.c. Evidence-Based Reasoning Graphic

EDUCATOR RESOURCES
From Lesson 6:
- 7.d. Teacher Observation Protocol: Try Lesson
- 7.e. Teacher Observation Protocol: Redesign

a. My response:
b. Team response:

B. Look back in your Engineering Notebook to see how you developed your solution throughout solving the problem. **How has your <u>understanding of how to design a solution changed</u> during the design process?** Think in terms of what you did and how you made decisions to solve the problem.

a. My response:
b. Team response:

C. **How do <u>engineers solve problems</u>?**

a. My response:
b. Team response:

Have students share and discuss their answers with their team. Below their own response, have students write their revised answer to the questions using a different color writing utensil to distinguish their own answer and how it changed after talking with their teammates.

2. **Reflect on the learning and teaming in the unit.** Ask students to respond to the following reflective prompts in their engineering notebooks.
   - *Describe how your thinking changed throughout the unit.*
   - *Describe how you contributed to your team.*
   - *Explain what you did as a team that was successful, and reflect on how you might have improved your teamwork.*

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LESSON 7

Redesign and Reporting

LESSON 7

Name________________________________ Date___________ Period _____

7.a. Your Best Nest Platform Redesign

Planning:
Describe, in detail, what you are changing on your platform after your first test. Why?

Redesign Budget Sheet:
Even if you are reusing materials from your original platform, you must account for them in this budget sheet!

Name of Item	Cost per Item	Quantity	Total Cost of Individual Item
			Total Cost of All Items	

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LESSON 7

Name________________________________ Date____________ Period _____

7.b. Your Best Nest Platform Scoring Guide

Scoring/Criteria				Your Score
Buoyancy (Does it float when loon is added?)	0 No, it doesn't float	5 It floats for 1-2 minutes	10 Yes, it floats for more than 2 minutes	
Stability in waves	0 Tips over in waves or damaged beyond repair	5 Has little damage, partially tipped over in waves	10 Remains upright, no damage	
Privacy/ Protection	0 Loon is totally open and exposed to predators	8 Loon is partially protected from overhead predators	15 Loon is mostly protected from overhead predators	
Water Access	0 Platform does not allow adults or chicks to easily access to water	5 Platform allows adults or chicks to easily access to water but not both	10 Platform allows adults and chicks to easily access to water	
Cost	0 $50.00 or more	5 $20.01 to $49.99	10 $20.00 or less	

Total Score______________

LESSON 7

Name________________________________ Date___________ Period _____

7.c. Evidence-Based Reasoning Graphic

Problem with Criteria & Constraints (What do you need to worry about?)	
Problem: **Criteria:** **Constraints:**	
Simplifying Assumptions (What do you not need to worry about?)	
Plan (Design Idea)	**Data/Evidence** (Facts)
Explanation, Justification, Reasoning (Why do you think this will work?)	

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LESSON 7

7.d. Teacher Observation Protocol: Try Lesson

Directions:
This is an observation assessment. The main purpose of this assessment is to observe evidence that student teams are working together to make their solution. In addition, this is opportunity to further assess that students are making design-decisions based on understanding the problem.

- **Part 1:** As you walk around to each team, please put a check by the behaviors you observe.
- **Part 2:** Interact with each team to assess their progress on the project. You may choose to ask some of the following questions or your own questions. You may also choose to add (or not) your own additional teaming-related assessment, as you deem appropriate. There is space for you to take notes of your observations.

Part 1: Behaviors

☐ All team members are on-task to make/try their solution.

☐ One or more team members are not on-task.

Notes:

☐ Team has made appropriate progress on their solution.

☐ Team is struggling to make their solution.

Notes:

☐ Team is making/made a solution directly related to problem.

☐ Team is making/made a something unrelated to problem.

Notes:

7.d. Teacher Observation Protocol: Try Lesson

Directions:
This is an observation assessment. The main purpose of this assessment is to observe evidence that student teams are working together to make their solution. In addition, this is opportunity to further assess that students are making design-decisions based on understanding the problem.

- **Part 1:** As you walk around to each team, please put a check by the behaviors you observe.
- **Part 2:** Interact with each team to assess their progress on the project. You may choose to ask some of the following questions or your own questions. You may also choose to add (or not) your own additional teaming-related assessment, as you deem appropriate. There is space for you to take notes of your observations.

Part 1: Behaviors

☐ All team members are on-task to make/try their solution.

☐ One or more team members are not on-task.

Notes:

☐ Team has made appropriate progress on their solution.

☐ Team is struggling to make their solution.

Notes:

☐ Team is making/made a solution directly related to problem.

☐ Team is making/made a something unrelated to problem.

Notes:

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7.e. Teacher Observation Protocol: Redesign Lesson

Directions:
This is an observation assessment. The main purpose of this assessment is to observe whether teams are testing their redesigned solution and analyzing results. In addition, this is opportunity to further assess that students are making design-decisions based on understanding the problem.

- **Part 1:** As you walk around to each team, please put a check by the behaviors you observe.
- **Part 2:** Interact with each team to assess their progress on the project. You may choose to ask some of the following questions or ask your own questions. You may also choose to add (or not) your own additional teaming-related assessment, as you deem appropriate. There is space for you to take notes of your observations.

Part 1: Behaviors Testing Improved Solution

☐ All team members are on-task to retest solution.

☐ One or more team members are not on-task.

Notes:

☐ Team has attempted to improve performance of solution.

☐ Unclear what improvements team made.

Notes:

Notebook Prompts and Titles

Teacher Directions:

If you prefer to have students write the answers to prompts right in their notebooks (rather than on the handouts and then adhere them to the notebooks), you should have the students put the bold title for each prompt and then answer the question that follows. The format for each will be as follows:

Prompt title:
Question to answer

Have students answer each set of questions as they appear in the curriculum. If any questions are included in the curriculum, but not included here, you may determine the title for the prompt.

Problem Scoping Lessons - Define and Learn

Section 1:

Engineers:
What do engineers do?
Solve Problems:
How do engineers solve problems?

Section 2:

Questions for client:
What questions do you want to ask to the client?

Section 3:

Client:
Who is the client?

Problem:
What is the client's problem that needs a solution?

Why it is important:
Why is the problem important to solve?

End-users:
Who are the end-users?

Criteria:
What will make the solution effective (criteria)?

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Notebook Prompts and Titles

Constraints:
What will limit how you can solve the problem (constraints)?

What we need to learn:
Think about the problem of human encroachment on loon nesting sites. What do you need to learn in order to select a suitable lake and build a loon nesting platform?

Generate Ideas/Plan Lessons

Section 1:

EBR Graphics can just be drawn in notebooks.

Section 2:

Have students answer the following after EBR graphics are complete.

Pros and Cons:
What are the pros and cons of each of your solutions?

Why we chose our solution:
Which solution did your team choose and why?

Test Solution Idea(s) Lessons

Section 1:

Ask students to complete after they have run their tests.

Learned from test results:
What have you learned about the performance of your solution from your test results?

Changes from test results:
What changes will you make to your solution based on the results of your tests? Explain why you want to make those changes.

Changes from science/math learned:
What improvements will you make to your solution based on the science and/or math you have learned? Explain why you want to make those changes.

Notebook Prompts and Titles

Section 2:

Section 2 questions should come after the students have run their tests and have had an opportunity to answer Section 1 questions.

How solution meets criteria and constraints:
In what ways does your solution meet the criteria and constraints of the problem?

How solution does not yet meet criteria and constraints:
In what ways does your solution not yet meet the criteria and constraints of the problem?

Changed problem description:
Go back and look at how you described the problem right after talking with the client. How would you change your description of the problem now that you have planned, tried, and tested a solution? (Think about criteria, constraints, client need, and/or things you need to learn.)

Decide/Final Solution Lessons

Section 1:

Students use evidence-based reasoning in reporting their final solution to the client. This can happen through use of the EBR graphic as part of their memo or presentation, or you can have the students include the aspects of the EBR graphic (without the graphic itself) in the memo or the presentation.

Section 2:

These questions should be completed after presenting the solution to the client and the entire design challenge is complete.

Understanding of the problem:
Look back in your Engineering Notebook to see how you defined the problem throughout solving the problem. *How has your understanding of the problem changed during the design process?* Think in terms of client needs, criteria, constraints, and the science and mathematics needed to solve the problem.

Understanding of designing a solution:
Look back in your Engineering Notebook to see how you developed your solution throughout solving the problem. *How has your understanding of how to design a solution changed during the design process?* Think in terms of what you did and how you made decisions to solve the problem.

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