



# Springfield Public Schools
Springfield, New Jersey 07081

## PLTW Launch
Grade 5

## Curriculum Guide

## 2022

This curriculum may be modified through varying materials, techniques, and strategies as per an individual student's IEP.

*Springfield Board of Education*
*Approved July 25, 2022*

# Springfield Public Schools
# Springfield, New Jersey

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*"Cultivating compassionate and extraordinary learners"*

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Resolution: School Government
Introduced By: Mr. Miller
Seconded By: Mrs. Gamarekian
Adopted: July 25, 2022

**Curriculum Adoption**

To adopt the following curriculum and courses for the 2022-2023 school year:

- Revised Elementary Curriculum due to revised state standards.
  - K-5 Social Studies
- Revised Middle School Curriculum due to revised state standards.
  - Grades 6-8 Social Studies
- Revised High School Curriculum due to revised state standards.
  - AP Macroeconomics
  - AP European History
  - AP US Government & Politics
  - AP US History
  - Contemporary Global Studies
  - Diversity Studies
  - Holocaust & Genocide
  - Sociology
  - US History to 1900
  - World History
  - World History Honors
  - 20th Century & Beyond
- Revised Middle School Courses due to new standards in Computer Science
  - PLTW Gateway: Computer Science for Innovators and Makers
  - PLTW Gateway: App Creators
- Revised High School Courses due to new standards in Computer Science
  - Introduction to Java
  - AP Computer Science Principles
  - Advanced Computer Science - Data Structures: Java
- New Elementary Courses
  - Kindergarten Computer Science
  - Grade 1 Computer Science
  - Grade 2 Computer Science
  - Anticipated - moving PLTW Launch down to Grade 3
  - PLTW Launch Grade 4
  - PLTW Launch Grade 5
- New Middle School Elective Course
  - Forensics

- New Elective Courses at FMG
  - Creative Writing
  - Drama/Theater/Playwriting
  - Journalism
  - Mock Trial
  - Model UN
  - Mysteries in History
  - Project Citizen
- New ELA Courses at FMG
  - Accelerated Communication Arts Grade 7
  - Accelerated Communication Arts Grade 8
- New Elective Courses at JDHS:
  - African American Studies

I, Michelle Calas, School Business Administrator/Board Secretary of the Springfield Board of Education, hereby certify that the extract from the minutes of a meeting of the Board of Education duly called and held on July 25, 2022 has been compared by me with the original minute book of said Board of Education, and is a true, complete and exact copy therefor, as far as the same relates to the subject matter referred to said contract.

IN WITNESS THEREOF, I have hereunto set my hand and seal of the Springfield Board of Education, this 26th of July 2022.

SEAL

Michelle Calas
School Business Administrator/Board Secretary

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# New Jersey Student Learning Standards

## Science

- 5-PS1-1 Develop a model to describe that matter is made of particles too small to be seen.
- 5-PS1-2 Measure and graph quantities to provide evidence that regardless of the type of change that occurs when heating, cooling, or mixing substances, the total weight of matter is conserved.
- 5-PS1-3 Make observations and measurements to identify materials based on their properties.
- 5-PS1-4 Conduct an investigation to determine whether the mixing of two or more substances results in new substances.
- 5-PS2-1 Support an argument that the gravitational force exerted by Earth on objects is directed down.
- 5-PS3-1 Use models to describe that energy in animals' food (used for body repair, growth, motion, and to maintain body warmth) was once energy from the sun.
- 5-LS1-1 Support an argument that plants get the materials they need for growth chiefly from air and water.
- 5-LS2-1 Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.
- 5-ESS1-1 Support an argument that differences in the apparent brightness of the sun compared to other stars is due to their relative distances from Earth.
- 5-ESS2-1 Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.
- 5-ESS2-2 Describe and graph the amounts of salt water and fresh water in various reservoirs to provide evidence about the distribution of water on Earth.
- 5-ESS3-1 Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources, environment, and address climate change issues.
- 3-5-ETS1-1 Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
- 3-5-ETS1-2 Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
- 3-5-ETS1-3 Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

## Science and Engineering Practices

**Developing and Using Models**
Modeling in 3–5 builds on K–2 experiences and progresses to building and revising simple models and using models to represent events and design solutions.

- Develop a model to describe phenomena. (5-PS1-1), (5-PS3-1), (5-LS2-1)
- Develop a model using an example to describe a scientific principle. (5-ESS2-1)

**Planning and Carrying Out Investigations** Planning and carrying out investigations to answer questions or test solutions to problems in 3–5 builds on K–2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions.

- Conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. (5-PS1-4)
- Make observations and measurements to produce data to serve as the basis for evidence for an explanation

of a phenomenon. (5-PS1-3)

- Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. (3-5-ETS1-3)

**Using Mathematics and Computational Thinking**

Mathematical and computational thinking in 3–5 builds on K–2 experiences and progresses to extending quantitative measurements to a variety of physical properties and using computation and mathematics to analyze data and compare alternative design solutions.

- Measure and graph quantities such as weight to address scientific and engineering questions and problems. (5-PS1-2)
- Mathematical and computational thinking in 3 - 5 builds on K - 2 experiences and progresses to extending quantitative measurements to a variety of physical properties and using computation and mathematics to analyze data and compare alternative design solutions.
- Describe and graph quantities such as area and volume to address scientific questions. (5-ESS2-2)

**Engaging in Argument from Evidence**

Engaging in argument from evidence in 3–5 builds on K–2 experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world(s).

- Support an argument with evidence, data, or a model. (5-PS2- 1), (5-LS1- 1), (5- ESS1-1)

**Analyzing and Interpreting Data**

Analyzing data in 3–5 builds on K–2 experiences and progresses to introducing quantitative approaches to collecting data and conducting multiple trials of qualitative observations. When possible and feasible, digital tools should be used.

- Represent data in graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships. (5- ESS1-2)

**Obtaining, Evaluating, and Communicating Information**

Obtaining, evaluating, and communicating information in 3–5 builds on K–2 experiences and progresses to evaluating the merit and accuracy of ideas and methods.

- Obtain and combine information from books and/or other reliable media to explain phenomena or solutions to a design problem. (5- ESS3-1)

**Asking Questions and Defining Problems**

Asking questions and defining problems in 3–5 builds on grades K– 2 experiences and progresses to specifying qualitative relationships.

- Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost. (3-5-ETS1-1)

**Constructing Explanations and Designing Solutions**

Constructing explanations and designing solutions in 3–5 builds on K–2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems.

- Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design problem. (3-5-ETS1-2)

# Disciplinary Core Ideas (DCIs)

**PS1.A: Structure and Properties of Matter**

- Matter of any type can be subdivided into particles that are too small to see, but even then the matter still exists and can be detected by other means. A model showing that gasses are made from matter particles that are too small to see and are moving freely around in space can explain many observations, including the inflation and shape of a balloon and the effects of air on larger particles or objects. (5-PS1-1)
- The amount (weight) of matter is conserved when it changes form, even in transitions in which it seems to vanish. (5-PS1-2)
- Measurements of a variety of properties can be used to identify materials. (Boundary: At this grade level, mass and weight are not distinguished, and no attempt is made to define the unseen particles or explain the atomic-scale mechanism of evaporation and condensation.) (5-PS1-3)

**PS1.B: Chemical Reactions**

- When two or more different substances are mixed, a new substance with different properties may be formed. (5-PS1-4)
- No matter what reaction or change in properties occurs, the total weight of the substances does not change. (Boundary: Mass and weight are not distinguished at this grade level.) (5-PS1-2)

**PS2.B: Types of Interactions**

- The gravitational force of Earth acting on an object near Earth's surface pulls that object toward the planet's center. (5-PS2-1)

**PS3.D: Energy in Chemical Processes and Everyday Life**

- The energy released [from] food was once energy from the sun that was captured by plants in the chemical process that forms plant matter (from air and water). (5- PS3-1)

**LS1.C: Organization for Matter and Energy Flow in Organisms**

- Plants acquire their material for growth chiefly from air and water. (5-LS1-1)
- Food provides animals with the materials they need for body repair and growth and the energy they need to maintain body warmth and for motion. (secondary to 5-PS3-1)

**LS2.A: Interdependent Relationships in Ecosystems**

- The food of almost any kind of animal can be traced back to plants. Organisms are related in food webs in which some animals eat plants for food and other animals eat the animals that eat plants. Some organisms, such as fungi and bacteria, break down dead organisms (both plants or plants parts and animals) and therefore operate as "decomposers." Decomposition eventually restores (recycles) some materials back to the soil. Organisms can survive only in environments in which their particular needs are met. A healthy ecosystem is one in which multiple species of different types are each able to meet their needs in a relatively stable web of life. Newly introduced species can damage the balance of an ecosystem. (5-LS2- 1)

**LS2.B: Cycles of Matter and Energy Transfer in Ecosystems**

- Matter cycles between the air and soil and among plants, animals, and microbes as these organisms live and die. Organisms obtain gasses, and water, from the environment, and release waste matter (gas, liquid, or solid) back into the environment. (5-LS2-1)

**ESS1.A: The Universe and its Stars**

- The sun is a star that appears larger and brighter than other stars because it is closer. Stars range greatly in their distance from Earth. (5-ESS1-1)

**ESS1.B: Earth and the Solar System**

- The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns. These include day and night; daily changes in the length and direction of shadows; and different positions of the sun, moon, and stars at different times of the day, month, and year. (5- ESS1-2)

**ESS2.A: Earth Materials and Systems**

- Earth's major systems are the geosphere (solid and molten rock, soil, and sediments), the hydrosphere (water and ice), the atmosphere (air), and the biosphere (living things, including humans). These systems interact in multiple ways to affect Earth's surface materials and processes. The ocean supports a variety of ecosystems and organisms, shapes landforms, and influences climate. Winds and clouds in the atmosphere interact with the landforms to determine patterns of weather. (5-ESS2-1)

**ESS2.C: The Roles of Water in Earth's Surface Processes**

- Nearly all of Earth's available water is in the ocean. Most freshwater is in glaciers or underground; only a tiny fraction is in streams, lakes, wetlands, and the atmosphere. (5-ESS2-2)

**ESS3.C: Human Impacts on Earth Systems**

- Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. But individuals and communities are doing things to help protect Earth's resources and environments. (5-ESS3-1)

**ETS1.A: Defining and Delimiting Engineering Problems**

- Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. (3-5- ETS1-1)

**ETS1.B: Developing Possible Solutions**

- Research on a problem, such as climate change, should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions. (3-5-ETS1-2)
- At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. (3-5-ETS1-2)
- Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. (3-5-ETS1-3)

**ETS1.C: Optimizing the Design Solution**

- Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (3-5-ETS1-3)

# Crosscutting Concepts

**Cause and Effect**

- Cause and effect relationships are routinely identified, tested, and used to explain change. (5-PS1-4), (5-PS2-1)

**Scale, Proportion, and Quantity**

- Natural objects exist from the very small to the immensely large. (5- PS1-1), (5- ESS1-1)
- Standard units are used to measure and describe physical quantities such as weight, time, temperature, and volume. (5-PS1-2), (5-PS1-3), (5- ESS2-2)

**Energy and Matter**

- Energy can be transferred in various ways and between objects. (5-PS3-1)
- Matter is transported into, out of, and within systems. (5-LS1-1)

**Systems and System Models**

- A system can be described in terms of its components and their interactions. (5-LS2-1), (5-ESS2-1), (5-ESS3-1)

**Patterns**

- Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena. (5-ESS1-2)

**Influence of Engineering, Technology, and Science on Society and the Natural World**

- People's needs and wants change over time, as do their demands for new and improved technologies. (3-5-ETS1-1)
- Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands. (3-5-ETS1-2)

***Connections to Nature of Science***

**Scientific Knowledge Assumes an Order and Consistency in Natural Systems**

- Science assumes consistent patterns in natural systems. (5- PS1-2)

**Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena**

- Science explanations describe the mechanisms for natural events. (5- LS2-1)

**Science Addresses Questions About the Natural and Material World**

- Science findings are limited to questions that can be answered with empirical evidence. (5-ESS3- 1)

## Computer Science and Design Thinking (Standard 8)

- 8.1.5.CS.1: Model how computing devices connect to other components to form a system.
- 8.1.5.CS.2: Model how computer software and hardware work together as a system to accomplish tasks.
- 8.1.5.CS.3: Identify potential solutions for simple hardware and software problems using common troubleshooting strategies.
- 8.1.5.NI.1: Develop models that successfully transmit and receive information using both wired and wireless methods.
- 8.1.5.NI.2: Describe physical and digital security measures for protecting sensitive personal information.
- 8.1.5.IC.1: Identify computing technologies that have impacted how individuals live and work and describe the factors that influenced the changes.
- 8.1.5.IC.2: Identify possible ways to improve the accessibility and usability of computing technologies to address the diverse needs and wants of users.
- 8.1.5.DA.1: Collect, organize, and display data in order to highlight relationships or support a claim.
- 8.1.5.DA.2: Compare the amount of storage space required for different types of data.
- 8.1.5.DA.3: Organize and present collected data visually to communicate insights gained from different views of the data.
- 8.1.5.DA.4: Organize and present climate change data visually to highlight relationships or support a claim.
- 8.1.5.DA.5: Propose cause and effect relationships, predict outcomes, or communicate ideas using data.
- 8.1.5.AP.1: Compare and refine multiple algorithms for the same task and determine which is the most appropriate.
- 8.1.5.AP.2: Create programs that use clearly named variables to store and modify data.
- 8.1.5.AP.3: Create programs that include sequences, events, loops, and conditionals.
- 8.1.5.AP.4: Break down problems into smaller, manageable sub-problems to facilitate program development.
- 8.1.5.AP.5: Modify, remix, or incorporate pieces of existing programs into one's own work to add additional features or create a new program.
- 8.1.5.AP.6: Develop programs using an iterative process, implement the program design, and test the program to ensure it works as intended.
- 8.2.5.ED.1: Explain the functions of a system and its subsystems.
- 8.2.5.ED.2: Collaborate with peers to collect information, brainstorm to solve a problem, and evaluate all possible solutions to provide the best results with supporting sketches or models.
- 8.2.5.ED.3: Follow step by step directions to assemble a product or solve a problem, using appropriate tools to accomplish the task.
- 8.2.5.ED.4: Explain factors that influence the development and function of products and systems (e.g., resources, criteria, desired features, constraints).
- 8.2.5.ED.5: Describe how specifications and limitations impact the engineering design process.
- 8.2.5.ED.6: Evaluate and test alternative solutions to a problem using the constraints and tradeoffs identified in the design process.
- 8.2.5.ITH.1: Explain how societal needs and wants influence the development and function of a product and a system.
- 8.2.5.ITH.2: Evaluate how well a new tool has met its intended purpose and identify any shortcomings it might have.
- 8.2.5.ITH.3: Analyze the effectiveness of a new product or system and identify the positive and/or negative

consequences resulting from its use.

- 8.2.5.ITH.4: Describe a technology/tool that has made the way people live easier or has led to a new business or career.
- 8.2.5.NT.1: Troubleshoot a product that has stopped working and brainstorm ideas to correct the problem.
- 8.2.5.NT.2: Identify new technologies resulting from the demands, values, and interests of individuals, businesses, industries, and societies.
- 8.2.5.NT.3: Redesign an existing product for a different purpose in a collaborative team. 8.2.5.ETW.1: Describe how resources such as material, energy, information, time, tools, people, and capital are used in products or systems.
- 8.2.5.NT.4: Identify how improvement in the understanding of materials science impacts technologies.
- 8.2.5.ETW.1: Describe how resources such as material, energy, information, time, tools, people, and capital are used in products or systems.
- 8.2.5.ETW.2: Describe ways that various technologies are used to reduce improper use of resources.
- 8.2.5.ETW.3: Explain why human-designed systems, products, and environments need to be constantly monitored, maintained, and improved.
- 8.2.5.ETW.4: Explain the impact that resources, such as energy and materials used to develop technology, have on the environment.
- 8.2.5.ETW.5: Identify the impact of a specific technology on the environment and determine what can be done to increase positive effects and to reduce any negative effects, such as climate change.
- 8.2.5.EC.1: Analyze how technology has contributed to or reduced inequities in local and global communities and determine its short- and long-term effects

## Career Readiness, Life Literacies, and Key Skills (Standard 9)

- 9.2.5.CAP.1: Evaluate personal likes and dislikes and identify careers that might be suited to personal likes.
- 9.2.5.CAP.3: Identify qualifications needed to pursue traditional and non-traditional careers and occupations.
- 9.2.5.CAP.4: Explain the reasons why some jobs and careers require specific training, skills, and certification (e.g., life guards, child care, medicine, education) and examples of these requirements.
- 9.2.5.CAP.6: Compare the characteristics of a successful entrepreneur with the traits of successful employees.
- 9.4.5.CI.2: Investigate a persistent local or global issue, such as climate change, and collaborate with individuals with diverse perspectives to improve upon current actions designed to address the issue (e.g., 6.3.5.CivicsPD.3, W.5.7).
- 9.4.5.CI.3: Participate in a brainstorming session with individuals with diverse perspectives to expand one's thinking about a topic of curiosity (e.g., 8.2.5.ED.2, 1.5.5.CR1a).
- 9.4.5.CI.4: Research the development process of a product and identify the role of failure as a part of the creative process (e.g., W.4.7, 8.2.5.ED.6).
- 9.4.5.CT.1: Identify and gather relevant data that will aid in the problem-solving process (e.g., 2.1.5.EH.4, 4-ESS3-1, 6.3.5.CivicsPD.2).
- 9.4.5.CT.2: Identify a problem and list the types of individuals and resources (e.g., school, community agencies, governmental, online) that can aid in solving the problem (e.g., 2.1.5.CHSS.1, 4-ESS3-1).
- 9.4.5.CT.3: Describe how digital tools and technology may be used to solve problems.
- 9.4.5.CT.4: Apply critical thinking and problem-solving strategies to different types of problems such as personal, academic, community and global (e.g., 6.1.5.CivicsCM.3).
- 9.4.5.DC.4: Model safe, legal, and ethical behavior when using online or offline technology (e.g., 8.1.5.NI.2).
- 9.4.5.IML.2: Create a visual representation to organize information about a problem or issue (e.g., 4.MD.B.4,

8.1.5.DA.3).

- 9.4.5.IML.3: Represent the same data in multiple visual formats in order to tell a story about the data.
- 9.4.5.TL.1: Compare the common uses of at least two different digital tools and identify the advantages and disadvantages of using each.
- 9.4.5.TL.2: Sort and filter data in a spreadsheet to analyze findings.
- 9.4.5.TL.4: Compare and contrast artifacts produced individually to those developed collaboratively (e.g., 1.5.5.CR3a).
- 9.4.5.TL.5: Collaborate digitally to produce an artifact (e.g., 1.2.5CR1d).

Introduction to the Module

# Earth's Water and Interconnected Systems

Teacher Resources



**Distance Learning Support**

For information about PLTW's distance learning support and online learning guides, jump to Distance Learning Support in **PLTW Launch Module-specific PD Resources**.

For distance learning support for facilitating this module, jump to **Distance Learning Support: Earth's Water and Interconnected Systems Teacher Guide**.

## PREFACE

**Time**: 10 instructional hours

In this module, students learn about Earth's systems: the atmosphere, hydrosphere, geosphere, and biosphere. Students examine how these systems interact and examine the role of gravity within each system.

After students establish an understanding of Earth's four major systems, they take an in-depth look at how the processes of the water cycle intersect with each of the systems and apply this knowledge to investigate factors that impact the rate of evaporation using the scientific inquiry process. In the problem, students use the engineering design process to develop a method for producing clean drinking water from samples of contaminated water.

## RESOURCES

R

Device Specifications

Application List

## Preparation

Are you ready to teach this module? Hold it right there! As you may remember from PLTW Launch Classroom Teacher Training, to create an engaging learning experience for your students, planning is essential.

This Teacher Guide includes resources you need for both planning and facilitation. The following outline lists the general resources designed to help you prepare to teach this module to your students.

- Curriculum Framework and Connections to Standards >
- Professional Development >
- Community >
- Rostering Students >
- Family and Community Relationships >
- PLTW Launch Logs >
- Developing Vocabulary >
- Icon Legend >
- Additional Instructional Resources >
- Curriculum Revisions >

Introduction Story

# The Big Hike

Teacher Resources

View Student Course

RESOURCE

R

Introduction Story: The Big Hike

**Time**: 20 Minutes

## Introduction

To set the stage for learning, guide students to read the Introduction Story: *The Big Hike*, a fictional story that introduces the problem. You may print the story if needed.

1. Introduce students to the student course and assist them with the log-in process on a digital device. For the rest of the module, students will access the curriculum in the student course.
2. Guide students to access the Introduction Story: *The Big Hike*. Students can read or listen to the story using audio in small groups. Alternatively, you may read the story aloud as a class.
3. Use the guiding questions within the story to engage students in thinking about ideas and concepts throughout the module. Use this time of discussion to uncover what your students already know about the concepts, what they are curious about, and what misconceptions they have. Consider how this formative assessment of students can guide you as you facilitate the activities, project, and problem in this module. To set the purpose for the learning experiences to come, it's also important to guide students to identify the problem.
4. Throughout the module, students can reread the story to remind themselves of the problem they will be solving.

Activity 1

# Earth Systems

Teacher Resources

View Student Course

## EQUIPMENT

This list is based on a class of 30 students.

| Not Included in Equipment Kit | Device Application |
|---|---|
| • PLTW Launch Logs (1 per student)<br>• Digital devices<br>• Pencils or colored pencils for sketching<br>• Chart paper<br>• Markers<br>• Index cards | • Inkling |

## ESSENTIAL QUESTIONS

EQ

EQ1 How do Earth's major systems interact?
EQ2 Is there enough fresh water on Earth?
EQ3 How can a step-by-step process help you design or improve a solution to a problem?

## LEARNING OBJECTIVES

LO

LO1.2 Use scientific reasoning to ask questions, make observations, and investigate ideas to acquire knowledge and solve problems.
LO2.1 Analyze interactions between two Earth systems at a time.
LO4 Understand that science ideas can be used to protect humans, Earth's resources, and its environment.
LO6 Collaborate effectively on a diverse and multidisciplinary team.
LO7 Communicate effectively for specific purposes using the appropriate platform, tool, format, or digital media.
LO8 Practice ethical behavior in all settings.

## KNOWLEDGE AND SKILLS

KS

KS1.2.1 Ask and identify questions to gain knowledge or solve problems.
KS1.2.2 Make observations to draw conclusions of phenomena.
KS2.1.1 Identify the hydrosphere, atmosphere, biosphere, and geosphere.
KS2.1.2 Explain how the hydrosphere, biosphere, atmosphere, and geosphere interact.
KS2.1.3 Understand the role of gravity within each system.
KS4.2 Understand that science findings are limited to questions that can be answered with evidence.
KS6.1 Generate ideas as a team.
KS6.2 Value the contributions of each team member.
KS6.3 Demonstrate collaboration through effective communication.
KS7.1 Document work in an organized notebook.
KS7.2 Explain findings and justify evidence-based conclusions with others.
KS7.3 Present data and information accurately and effectively.
KS8.1 Engage in and maintain positive interactions and relationships with other children and adults.

## Introduction

Earth is a complex collection of interconnected *systems*. Events that happen within one system of the global environment can have a ripple effect into other systems. There is constant interaction between the systems.

In this activity, students learn about four of *Earth's systems*: the *hydrosphere*, *geosphere*, *atmosphere*, and *biosphere*. They explore how the systems, along with *gravity*, impact and interact with one another.

## Preparation

### Part 1. Earth

1. Become familiar with the vocabulary terms used in this activity. Plan how you will help students use these terms as part of their vocabulary.

| | |
|---|---|
| atmosphere | All the gases that surround Earth. |
| biosphere | All the living things on Earth. |
| Earth system | Earth's four major systems—atmosphere, biosphere, geosphere, and hydrosphere—that move energy and materials to create the world as we know it. |
| geosphere | All the rock, soil, and sediment that make up Earth's land. |
| gravity | A force that pulls objects toward Earth's center. |
| hydrosphere | All the oceans, rivers, lakes, and water on Earth. |
| system | A group of processes and parts that interact in a connected way. |

2. Review the Evidence (Stage 2) and Learning Plan (Stage 3) section of the **Curriculum Framework**. Use this tool to plan how you will formatively and summatively assess students throughout this activity.
3. Determine ways you can support the development of transportable skills in this module. Examples include calling out ways students demonstrate the skills, asking questions that allow students to reflect on their development of the skills, and integrating books listed in the Transportable Skills: Literature Connections resource.
4. Review the **Additional Instructional Resources**. This list includes books that offer diverse perspectives that can expand student understanding. Using these resources provides a sense of inclusion and belonging, and helps students make connections if the content is new to them.
5. To access a printable version of the Launch Log, go to **PLTW Launch Logs**.
6. Before you begin Activity 1, read the **Introduction Story: *The Big Hike*** with students.
7. Prepare a piece of chart paper titled, "Earth". Another option is to create the chart using the ShowMe Interactive Whiteboard app and project the chart for students to view.

| Earth | | | |
|---|---|---|---|
| Living Things | Land | Water | Air |
| | | | |

8. Brainstorm examples for the Earth chart that may not occur to students, such as rocks, minerals, humans, water vapor, soil, carbon dioxide, or volcano. Write these words on index cards so that they are available at the end of Part 1.

### Part 2. Earth Systems

Preview the **Earth Systems** interactive experience to become familiar with the content. Review the discussion questions in the Procedure.

#### Possible Student Misconceptions

- **Gravity only affects falling objects and humans**. All living things have adapted to Earth's gravity. For example, plants sense gravity, which is why their roots grow downward, rather than up. Nonliving things also feel the force of gravity, as seen by the direction water flows in a river.
- **Earth's systems operate independently and do not affect one another**. Events that happen within the global environment can cause a ripple effect of events in other systems. For example, an earthquake in the geosphere can cause a tsunami in the hydrosphere which can devastate the biosphere of land that it hits.

## Procedure

**Time**: 90 Minutes

## Part 1. Earth

1. Direct students to access Activity 1 in the student course and have them read the Introduction.
2. Students use PLTW Launch Logs to keep a record of their work as they progress through the module. Distribute a Grades 3–5 Launch Log to each student. In the notebook, they may take notes as they research, create sketches, and answer conclusion questions.
3. Have students prepare their PLTW Launch Logs for Activity 1.
4. Guide students to complete a Think-Pair-Share on the following questions:
   - What are examples of living things?
   - What things are part of the land?
   - What are the different types of bodies of water?
   - What makes up the air?

   **Note**: Think-Pair-Share is a strategy where students think individually, discuss ideas with a partner, and then share with the whole class. It increases participation and focus.
5. Have students record their responses to the Think-Pair-Share questions in their Launch Logs.
6. As the class shares, record the responses on the chart titled "Earth". Guide students to record the responses in their Launch Logs as you record them on the chart.
7. Ask students to reflect on the words in each column and provide evidence for why the word belongs in that column. Prompt students to support their claims with evidence.

   I placed *lake* in the water column because it is a liquid.
8. Display each index card you created in preparation and ask students which heading the word should go under. Write it on the chart and have students record these in their Launch Logs.

## Part 2. Introduction to Earth Systems

9. Explain that students will watch an interactive experience on the four Earth systems and how they interact with one another. Direct them to watch the interactive experience on their devices and take notes in their Launch Logs during the presentation.
10. Introduce the **Earth Systems** interactive experience. Guide students to work with a partner or small group to interact with the resource to build an understanding of the atmosphere, biosphere, geosphere, and hydrosphere. Have students take notes in their Launch Logs while they view the interactive experience.
11. Lead a discussion about the interactive experience.

    - What is a system? Direct students to access the flashcard example as you introduce the vocabulary term *system*.
    - What is an example of a system in your body?
    - What is an example of an Earth system? Direct students to access the flashcard example as you introduce the vocabulary term *Earth system*.
    - What system would you associate with land? Living things? Water? Air? Direct students to access the flashcard example as you introduce the vocabulary terms *geosphere*, *biosphere*, *hydrosphere*, and *atmosphere*.
    - How do pairs of systems interact?
    - Why is gravity important in each system? Direct students to access the flashcard example as you introduce the vocabulary term *gravity*.
12. Guide students to work in a small group to review the Earth system scenarios found in the student course.
    - Assign a scenario to each group. Multiple groups may use the same scenario if necessary depending on class size.
    - Direct groups to read the scenario and record their answers to the following questions in their Launch Logs:
      - Which Earth systems are involved?
      - How do the systems interact?
      - What is the role of gravity?

**Note**: Student responses for the role of gravity may vary.

### Scenario 1

Water evaporates from a lake, forms a cloud, and then rains back down to the ground.

- Which Earth systems are involved? Hydrosphere and atmosphere
- How do the systems interact? Water from the hydrosphere evaporates into the atmosphere to help with cloud formation.
- What is the role of gravity? Gravity causes the rain to fall down toward Earth.

### Scenario 2

Humans build a dam out of rock and sand.

- Which Earth systems are involved? Biosphere, geosphere, and hydrosphere
- How do the systems interact? Humans, who are part of the biosphere, use rocks from the geosphere to build a dam. The rocks block the flow of water which is part of the hydrosphere.
- What is the role of gravity? Gravity pulls the rocks down and holds them in place.

### Scenario 3

A plant takes in water from the soil through its roots.

- Which Earth systems are involved? Biosphere, hydrosphere, and geosphere
- How do the systems interact? Plants from the biosphere use water from the hydrosphere which is stored in the soil (geosphere). Also, the soil (geosphere) provides stability to the plant (biosphere).
- What is the role of gravity? Gravity causes the plant's roots to grow down and causes water to soak down into the soil.

### Scenario 4

A forest fire damages plants, animals, and trees.

- Which Earth systems are involved? Atmosphere and biosphere
- How do the systems interact? The dry air in the atmosphere contributes to a fire, damaging living things in the biosphere.
- What is the role of gravity? Gravity pulls cool air with oxygen to the base of the fire causing it to burn more intensely. Also, some trees may fall while the base of the tree burns. Gravity pulls the trees to the ground.

### Scenario 5

Humans burn fossil fuels, which produces carbon dioxide.

- Which Earth systems are involved? Biosphere, geosphere, and atmosphere
- How do the systems interact? Humans, who are part of the biosphere, burn fossil fuels that come from the geosphere. The carbon dioxide becomes part of the atmosphere.
- What is the role of gravity? In this photograph, the role of gravity is not easily observed.

### Scenario 6

A hurricane displaces animal habitats and causes trees to fall.

- Which Earth systems are involved? Hydrosphere, biosphere, and atmosphere
- How do the systems interact? Water from the hydrosphere makes its way onto land and disrupts the biosphere. Wind from the atmosphere causes destruction to the biosphere.
- What is the role of gravity? Gravity causes massive amounts of water from the hydrosphere to be pulled downward toward land. The wind from the atmosphere damages the trees, but gravity causes the trees and other objects fall over.

### Scenario 7

A volcano erupts spewing out lava and gases.

- Which Earth systems are involved? Atmosphere and geosphere
- How do the systems interact? The volcano (geosphere) when it erupts sends gases into the atmosphere.
- What is the role of gravity? Gravity causes the lava, or molten rock, to flow down the volcano.

**Scenario 8**

Humans harness or gain energy from the rivers to produce electricity.

- Which Earth systems are involved? Biosphere and hydrosphere
- How do the systems interact? Humans which are a part of the biosphere use energy from the hydrosphere.
- What is the role of gravity? Gravity causes the water to flow downstream.

13. Direct students to choose one member of the group to read their scenario out loud and other members to read the group's responses. Be sure that all group members participate in the share out. Project the scenario images from the student course while students read them aloud.

14. Optional extension: Assign two Earth systems to each group and guide the students to come up with their own scenario. Have the groups exchange their scenarios and answer the three questions.

15. Guide students to answer the Conclusion Questions. Lead a discussion for students to share their thoughts.

## Conclusion Questions Answer Key

**Note**: Conclusion Questions offer an opportunity for formative assessment. You may use them as a whole-class discussion or you may have students record ideas in their Launch Logs.

1. Which of Earth's systems do you think clouds belong to? Support your claim with evidence.

Student responses should demonstrate an understanding of Earth's systems. Responses might include:
Clouds could be classified as part of the atmosphere and hydrosphere. The hydrosphere includes water that is on the surface of the planet, underground, and in the air. A planet's hydrosphere can be liquid, vapor, or ice. Water vapor is most visible as clouds and fog. Clouds are formed when warm and moist air rises up, cools, and then expands in the atmosphere. The water vapor in the air condenses to form tiny water droplets which form the basis of clouds.

2. How does gravity play a role in Earth's systems? Give an example as evidence to support your claim.

Student responses should demonstrate an understanding of gravity and Earth's systems. Responses might include:
Plants (biosphere) draw water (hydrosphere) and nutrients from the soil (geosphere) and release water vapor into the atmosphere. Gravity causes water to flow downhill and plants move this water up into their stems. Gravity also holds the plant's roots in the soil, allowing the plant to take in water and nutrients.

Activity 2

# The Water Cycle

Teacher Resources

View Student Course

## EQUIPMENT

The list below is based on a class of 30 students.

| Included in the Equipment Kit | Not Included in Equipment Kit | Device Applications |
|---|---|---|
| • Aquarium/terrarium, plastic, without cover, 1½ gallon (8)<br>• Petri dishes (8)<br>• Plastic wrap<br>• Ice cube tray<br>• Large rubber bands (8)<br>• *A Drop Around the World* by Barbara Shaw McKinney<br>• Plastic cups | • PLTW Launch Logs (1 per student)<br>• Digital devices<br>• Pencils or colored pencils for sketching<br>• Chart paper<br>• Markers<br>• Fast-growing seeds, such as:<br>  ◦ Alfalfa<br>  ◦ Radish<br>  ◦ Chia<br>  ◦ Lettuce<br>  ◦ Basil<br>  ◦ Marigold<br>  ◦ Morning glory<br>• Potting soil<br>• Water<br>• Spray bottle | • Inkling<br>• Camera |

## ESSENTIAL QUESTIONS

EQ

EQ1 How do Earth's major systems interact?

EQ2 Is there enough fresh water on Earth?

EQ3 How can a step-by-step process help you design or improve a solution to a problem?

## LEARNING OBJECTIVES

LO

LO1.2 Use scientific reasoning to ask questions, make observations, and investigate ideas to acquire knowledge and solve problems.

LO2.1 Analyze interactions between two Earth systems at a time.

LO2.2 Understand how the water cycle connects the hydrosphere to the other spheres.

LO4 Understand that science ideas can be used to protect humans, Earth's resources, and its environment.

LO6 Collaborate effectively on a diverse and multidisciplinary team.

LO7 Communicate effectively for specific purposes using the appropriate platform, tool, format, or digital media.

LO8 Practice ethical behavior in all settings.

## KNOWLEDGE AND SKILLS

KS

| | |
|---|---|
| KS1.2.1 | Ask and identify questions to gain knowledge or solve problems. |
| KS1.2.2 | Make observations to draw conclusions of phenomena. |
| KS2.1.1 | Identify the hydrosphere, atmosphere, biosphere, and geosphere. |
| KS2.1.2 | Explain how the hydrosphere, biosphere, atmosphere, and geosphere interact. |
| KS2.1.3 | Understand the role of gravity within each system. |
| KS2.2.1 | Develop a basic understanding of how the Sun provides energy for the water cycle. |
| KS2.2.2 | Recognize that gravity causes streams and rivers to flow downhill and rain to fall. |
| KS2.2.3 | Define each component of the water cycle. |
| KS4.1 | Explore ways to protect Earth's resources and its environment. |
| KS4.2 | Understand that science findings are limited to questions that can be answered with evidence. |
| KS6.1 | Generate ideas as a team. |
| KS6.2 | Value the contributions of each team member. |
| KS6.3 | Demonstrate collaboration through effective communication. |
| KS7.1 | Document work in an organized notebook. |
| KS7.2 | Explain findings and justify evidence-based conclusions with others. |
| KS7.3 | Present data and information accurately and effectively. |
| KS8.1 | Engage in and maintain positive interactions and relationships with other children and adults. |

## Introduction

The *hydrosphere* is made up of all the water that is on the planet. It includes the oceans, rivers, and lakes, but also water that is underground and in the air. Earth is truly unique in its abundance of water, and this water is always on the move. Rain falling today may have *evaporated* from a distant ocean days before. The water you see in a river or stream may have been snow on a high mountaintop.

The movement of water is called the *water cycle*, and this cycle impacts all of the *Earth's systems*. It sustains life on Earth (*biosphere*) and shapes and connects the *geosphere*, *hydrosphere*, and *atmosphere* into an integrated system. In this activity, students construct a *terrarium* to model the water cycle and observe how it interacts with Earth's systems.

## Preparation

### Part 1. Building a Terrarium

1. Become familiar with the vocabulary terms used in this activity. Plan how you will help students use these terms as part of their vocabulary.

| | |
|---|---|
| condensation | The process of a gas turning into a liquid. |
| evaporation | The process of a liquid changing into a gas. |
| groundwater | Water that exists below Earth's surface. |
| precipitation | Water that falls to the ground as rain, snow, sleet or hail. |
| runoff | Precipitation that neither absorbs into the ground nor evaporates into the air and flows into places where water collects. |
| terrarium | A clear enclosure for keeping or raising plants or small animals indoors. |
| water cycle | The continuous movement of water on, above, and below Earth's surface. |

2. Review the Evidence (Stage 2) and Learning Plan (Stage 3) section of the **Curriculum Framework**. Use this tool to plan how you will formatively and summatively assess students throughout this activity.
3. Review the **Additional Instructional Resources**. This list includes books that offer diverse perspectives that can expand student understanding. Using these resources provides a sense of inclusion and belonging, and helps students make connections if the content is new to them.
4. Review the How to Assemble a Terrarium resource in the student course.
5. Pre-cut the plastic wrap. It should be large enough to hang over the sides of terrarium and be secured by a rubber band. You need one piece per group.
6. Gather all terrarium supplies. Each group needs:
   - A plastic container
   - Soil
   - A petri dish
   - A cup of water
   - A piece of plastic wrap
   - A rubber band
   - Fast-growing seeds, such as:
     - Alfalfa
     - Radish
     - Chia
     - Lettuce
     - Basil
     - Marigold
     - Morning glory
7. Plan how to distribute materials. Consider:
   - Assign a materials manager to each group. That person is responsible for picking up the materials from a supply table.
   - Have all materials sorted by group and placed in a box. You may have a student distribute one box per group or have one student per group pick up their group's box.
8. Make ice cubes the night before. Plan how to retrieve the cubes for the end of Part 1.
9. Create a space in the classroom for students to place their terrariums. The space should:
   - Receive some light. It is not a good idea to place the terrariums in direct sunlight. The sunlight might burn the plants. Look for a location that receives indirect sunlight.
   - Not be near a heat source. A heat source can overheat the terrarium and kill the plants inside.
   - Be accessible for students throughout the module. Students will observe their terrarium in the project and problem.

### Part 2. The Hydrosphere

1. Prepare a piece of chart paper titled "Water on Earth". Another option is to create the chart using the ShowMe Interactive Whiteboard app and project the chart for students to view.

| Water on Earth |
| --- |
| |

2. Read the book *A Drop Around the World* by Barbara McKinney to become familiar with the content. Review the discussion questions in the Procedure.

## Part 3. The Water Cycle

Preview **The Water Cycle** interactive experience to become familiar with the content. Review the discussion questions in the Procedure.

### Possible Student Misconceptions

- **The water cycle includes only the process of evaporation and condensation**. The sun activates the water cycle by causing water to evaporate. After the water evaporates, it goes through several steps including condensation, sublimation, precipitation, transpiration, becoming runoff, and infiltration. The cycle affects all four of Earth's systems.
- **Water only evaporates from the ocean or lakes**. Water can also evaporate from plants, animals, puddles, and the ground. Evaporation is the process of a substance in a liquid state changing to a gaseous state due to an increase in temperature and/or pressure. This can happen anywhere water collects: in puddles, on leaves, and even on you when you get sweaty.

# Procedure

**Time**: 90 Minutes

## Part 1. Building a Terrarium

1. Direct students to access Activity 2 in the student course and have them read the Introduction.
2. Have students prepare their PLTW Launch Logs for Activity 2.
3. Direct students to access the flashcard example as you introduce the vocabulary term *terrarium*. Explain that a terrarium creates a closed environment that allows scientists to observe an ecosystem and its processes close up.
4. Introduce the terrarium activity. Explain that a model of a true ecosystem needs to include all four of Earth's systems. Direct students to access the flashcard examples as you review the vocabulary terms *system, geosphere*, *biosphere*, *hydrosphere*, and *atmosphere*. Direct students to refer to their Earth chart in their Launch Logs from Activity 1.
5. Guide students to view the terrarium materials.
6. Have students work with a small group to plan how they will use their materials to represent each of the four systems in their terrarium. Have students sketch their plans in their Launch Logs and label it with the four Earth systems. As students plan, circulate and ask students to explain how they will represent each Earth system.

   - How does the soil represent the geosphere?
   - What in your terrarium represents the biosphere? Why do you think this?
   - What in your terrarium represents the hydrosphere? Why do you think this?

7. Once students have a plan that incorporates all systems, direct them to build their terrariums. If students need additional support, you can provide a model, draw a diagram, or refer them to the How to Assemble a terrarium resource in the student course.
8. After the terrariums are complete, have students add a small amount of water to dampen the seeds and the soil. Explain that the soil should be damp, but not so wet that the seeds float. Consider having the students use a spray bottle to dampen the soil.
9. Direct students to cover the top of the terrarium with plastic wrap and secure it with a rubber band. Explain that the plastic wrap allows us to observe what happens in the terrarium, but keeps the ecosystem closed and controlled.
10. Guide students to draw a sketch of their terrarium in their Launch Logs and label each of the four Earth systems.
11. Distribute two ice cubes and have students place them on top of the plastic wrap on their terrariums.
12. Lead a discussion about the ice cubes.

- What will happen when we place ice cubes on top of the terrarium? Why do you think that?
- What will the ice cubes do to the air in the terrarium? How do you know that?

13. Have students place the terrariums in a safe place while the ice cubes melt.

## Part 2. The Hydrosphere

14. Ask students where water can be found on Earth. Record the responses on the chart paper titled, "Water on Earth".
15. Explain to students that water takes many different forms and moves all around the world.
16. Read the book *A Drop Around the World* aloud for students. You may choose to use a document viewer to project an image of the book. Direct students to listen for different forms of water named in the book and create a list of them in their Launch Logs.
17. Lead a discussion about the book.

- How is the hydrosphere represented in the story?
- What happens to Drop throughout the story? Direct students to access the flashcard example as you introduce the vocabulary term *water cycle*.
- What are some of the different forms of water represented in the story? Direct students to access the flashcard examples as you introduce the vocabulary terms *evaporation*, *condensation*, *precipitation*, *runoff*, and *groundwater*.
- How is Drop able to survive? Why do you think that?
- Where have you seen this phenomenon before? Tell me more.

18. Revisit the Water on Earth chart. Guide students to add any new forms of water to the list.

## Part 3. The Water Cycle

19. Introduce **The Water Cycle** interactive experience. Guide students to work with a partner or small group to interact with the resource to build an understanding of the water cycle. Have students take notes in their Launch Logs while they view the interactive experience.
20. Lead a discussion about the interactive experience.

- How does water move on Earth?
- What are some paths the water cycle can take?
- Do you think water always follows the same path? Why do you think that?
- Do you think water will ever disappear from Earth? Why do you think that?
- Use your knowledge of the water cycle to explain why the oceans are salty and other bodies of water are not.
- In what ways do humans depend on the water cycle? How do they benefit from it?

  All living things, including humans, depend on the water cycle because it makes fresh water available and regulates weather patterns. We benefit from the water cycle because we would not have clean water without it.

- How does this connect to your life?

21. Guide students to observe what happened in their terrarium. Have them take notes in their Launch Logs and take photos using their devices.
22. Guide students to explain their observations in terms of Earth's systems and the water cycle.

Example responses:

- The ice cube makes the air in the atmosphere cold, which causes water from the hydrosphere to cool and form tiny water droplets. These droplets fall down into the geosphere.
- Water from the petri dish and soil evaporated (hydrosphere and geosphere) into the air (atmosphere). The ice cubes cooled the air causing the water in the atmosphere to condense. When the condensation became too heavy, it rained back down onto Earth as precipitation.

**Note**: Students will observe their terrariums in the project and problem. You can have the students disassemble them at the end of the module, or you can allow the plants to grow throughout the school year. You cannot allow the student to take them home, as some materials are durable and need to be reused.

23. Guide students to answer the Conclusion Questions. Lead a discussion for students to share their thoughts.

## Conclusion Questions Answer Key

1 What role does gravity play in the water cycle?

Student responses should demonstrate an understanding of gravity and the water cycle. Responses might include:
As water droplets in the air join together and become heavier, gravity pulls on them. Eventually the force of gravity becomes stronger than the air currents holding the droplets up. This leads to precipitation.

2 How does the water cycle affect Earth's systems? Support your claims with evidence.

Student responses should demonstrate an understanding of the water cycle and Earth's systems. Responses might include:
The water cycle describes how water evaporates from the surface of Earth, rises into the atmosphere, cools, and condenses into rain or snow in clouds, and falls again to the surface as precipitation.

The water falling on land collects in rivers and lakes (hydrosphere), or seeps into the soil or rock (geosphere). It also lands on trees and plants (biosphere). This precipitation provides fresh drinking water for animals and humans (biosphere). Much of the water flows back into the oceans, where it will evaporate and begin the process again.

Activity 3

# Salt Water and Fresh Water

Teacher Resources

View Student Course

## EQUIPMENT

The list below is based on a class of 30 students.

| Included in the Equipment Kit | Not Included in Equipment Kit | Device Applications |
|---|---|---|
| • AuthaGraph world map<br>• Map cut into eight pieces<br>• Transparencies, with grid<br>• Dry-erase markers (1 package per group) | • PLTW Launch Logs (1 per student)<br>• Digital devices<br>• Pencils or colored pencils for sketching | • Inkling<br>• Calculator<br>• Presentation app, such as:<br>  ◦ Popplet Lite<br>  ◦ Mindomo<br>  ◦ ShowMe Interactive Whiteboard<br>• WaterSense for Kids |

## RESOURCE

R

Research Resources for Activity 3

## ESSENTIAL QUESTIONS

EQ

EQ1 How do Earth's major systems interact?
EQ2 Is there enough fresh water on Earth?
EQ3 How can a step-by-step process help you design or improve a solution to a problem?

## LEARNING OBJECTIVES

LO

LO1.2 Use scientific reasoning to ask questions, make observations, and investigate ideas to acquire knowledge and solve problems.
LO3 Analyze the fractional amounts of salt water, fresh water, and accessible fresh water.
LO4 Understand that science ideas can be used to protect humans, Earth's resources, and its environment.
LO5 Apply mathematical thinking to solve problems.
LO6 Collaborate effectively on a diverse and multidisciplinary team.
LO7 Communicate effectively for specific purposes using the appropriate platform, tool, format, or digital media.
LO8 Practice ethical behavior in all settings.

## KNOWLEDGE AND SKILLS

KS

| | |
|---|---|
| KS1.2.1 | Ask and identify questions to gain knowledge or solve problems. |
| KS1.2.2 | Make observations to draw conclusions of phenomena. |
| KS1.2.3 | Analyze data to look for patterns or to test whether data are consistent with an initial prediction. |
| KS3.1 | Identify the places that water is found on Earth. |
| KS3.2 | Explain how most fresh water is not readily available because it is found in glaciers, polar ice caps, or underground. |
| KS3.3 | Explain how humans, animals, and plants need fresh water in order to survive. |
| KS3.4 | Calculate the amount of salt water and fresh water on Earth. |
| KS4.1 | Explore ways to protect Earth's resources and its environment. |
| KS4.2 | Understand that science findings are limited to questions that can be answered with evidence. |
| KS5.2 | Reason abstractly and quantitatively. [CCSS.MATH.PRACTICE.MP2] |
| KS5.3 | Model with mathematics. [CCSS.MATH.PRACTICE.MP4] |
| KS5.4 | Use appropriate tools strategically. [CCSS.MATH.PRACTICE.MP5] |
| KS5.5 | Organize and present collected data visually to highlight relationships and support a claim. [1B-DA-06] |
| KS5.6 | Use data to highlight or propose cause-and-effect relationships, predict outcomes, or communicate an idea. [1B-DA-07] |
| KS6.1 | Generate ideas as a team. |
| KS6.2 | Value the contributions of each team member. |
| KS6.3 | Demonstrate collaboration through effective communication. |
| KS7.1 | Document work in an organized notebook. |
| KS7.2 | Explain findings and justify evidence-based conclusions with others. |
| KS7.3 | Present data and information accurately and effectively. |
| KS8.1 | Engage in and maintain positive interactions and relationships with other children and adults. |

## Introduction

Water is one of the most abundant resources on Earth, making up over 70 percent of Earth's surface. Although it is plentiful, it is not always accessible or useful to humans. Much of Earth's water is *salt water* found in the oceans. Salt water cannot be used for drinking or cooking without undergoing a process called desalination, the removal of salt.

*Fresh water* is water that does not contain salt. The most abundant source of fresh water is glacial ice, but this source is inaccessible. Accessible fresh water actually makes up a very small percentage of water on Earth. Instead, we get usable fresh water from rivers, lakes, streams, and *groundwater*. Groundwater is water that seeps underground after precipitation occurs. It travels through porous space and collects in the water table, a layer of Earth that is permanently saturated with water.

In this activity, students use a world map to examine where water can be found on Earth's surface. Students place a grid overlay on top of a region of the world. They calculate the total amount of water in their region and share their results with the class. The class combines their data to calculate the total amount of water in the world. Next, students research the amount of usable water on Earth and discuss its importance.

## Preparation

### Professional Development PD

Before you facilitate Activity 3, review the professional development resources.

- Access the **Launchpad** to review the resources:
  - Developing Research Skills with Elementary Students
  - Integrating Technology and Promoting Online Safety
  - Staying Safe and Secure! Interactive Experience
- Access the **Earth's Water and Interconnected Systems Module-specific PD Resources** to review Building Your Understanding: Distribution of Usable Water Around the World.

### Part 1. All the Water in the World

1. Become familiar with the vocabulary terms used in this activity. Plan how you will help students use these terms as part of their vocabulary.

| | |
|---|---|
| fresh water | Water that does not contain salt. |
| groundwater | Water that exists below Earth's surface. |
| salt water | Water that contains salt. |

2. Review the Evidence (Stage 2) and Learning Plan (Stage 3) section of the **Curriculum Framework**. Use this tool to plan how you will formatively and summatively assess students throughout this activity.
3. Review the **Additional Instructional Resources**. This list includes books that offer diverse perspectives that can expand student understanding. Using these resources provides a sense of inclusion and belonging, and helps students make connections if the content is new to them.

### Part 2. Sources of Water

During Part 2, students research sources and uses of water. Think about how you will facilitate this part. Consider the following options:

- Gather books about water, water sources, and the ways in which water is used.
- Review the **Research Resources for Activity 3** for suggested websites and keywords.

#### Possible Student Misconceptions

- **Since most of Earth is made up of water, there is plenty of water to drink**. Most of Earth's water is salt water and is not suitable for land plants and animals, including humans. Most of Earth's fresh water is either frozen in ice caps and glaciers, or located below the surface as groundwater, which is hard to access.
- **All of our drinking water comes from streams, lakes, and other visible, accessible sources**. River and stream water are important sources of water for humans. However, a large portion (about 33%) used by humans is obtained from groundwater.
- **Groundwater looks like flowing underground rivers or lakes**. Groundwater originates as rain or snow that seeps into the ground and reaches the water table. The water saturates the soil and is stored in between and inside of some rocks.
- **Most of Earth's fresh water occurs as liquid**. While we usually think of water as a liquid, it actually has three states: the liquid state, the solid state (also called ice), and the gaseous state (also called water vapor). Most of Earth's fresh water is glacial ice.
- **Earth's fresh water supply is fixed and does not change**. Evaporation in the oceans constantly purifies and replenishes fresh water supplies on land. Human use and climate changes can affect the amount of available fresh water.

## Procedure

**Time**: 130 Minutes

### Part 1. All the Water in the World

1. Direct students to access Activity 3 in the student course and have them read the Introduction.
2. Have students prepare their PLTW Launch Logs for Activity 3.
3. Guide students to respond with thumbs up or thumbs down to indicate whether they think these statements are true or false. Explain that they might not know the correct answer now, but by the end of the activity, they will have a better understanding of Earth's water resources.
   - Water can be found in rivers.
   - Water can be found in lakes.
   - Water can be found near Earth's poles.
   - Most of the fresh water on Earth is liquid.
   - Earth has more land than water.
4. Project the AuthaGraph World Map. Lead a discussion about the map's projection.

   - How does this map look different from other maps?

     **Note**: The AuthaGraph world map was invented by Hajime Narukawa, a Japanese architect. This style of map preserves the sizes and shapes of all oceans and continents. It avoids the distortions of other maps.

   - How are water features identified on the map?
   - What do you notice about the ratio of land to water?
5. Guide students to work in small groups. Distribute one section of the AuthaGraph World Map to each group.
6. Distribute a transparency with a grid to each group. Direct students to lay the grid on top of the map. Guide students to work with their group to use a dry-erase marker to color squares on the grid wherever water is present.
7. Lead a discussion about how to calculate area.

   - What is area?
   - How do you calculate area in math?
   - If you wanted to know the total area of your map, what is the easiest way to do this?

     The easiest way to calculate the total area of the AuthaGraph World Map is to count one row of squares going across and count one column of squares going down. Then, multiply the length times the width to find the area.

   - What are some strategies you could use to find the area of water on your map?

     Possible strategies include:
     - Count the number of colored squares.
     - Count the number of non-colored squares and subtract that number from the total number of squares.
     - Multiply the length times the width.
8. Guide students to calculate the area of colored squares on their map.
9. Direct students to determine the percentage of water on their maps. Students should divide the area of colored squares by the total number of squares of the map. Students may use the calculator on their digital devices as needed.
10. Have each group share their percentage with the class. Record the percentages on the board and guide the students to find the total percentage of water on Earth.
11. Lead a discussion about the amount of water on Earth.

- How much of Earth is covered in water? Does this number surprise you? Why or why not?
- Where is most of the water found? How do you know this?
- Is there water on the maps we cannot see? Why do you think this?
- Is most of the water on Earth salt water or fresh water? Why do you think that? Direct students to access the flashcard example as you introduce the vocabulary terms *salt water* and *fresh water*.

## Part 2. Sources of Water

12 Explain to students that they will now check the accuracy of the class average by conducting research about how much water is on Earth and how much of it is usable as drinking water. Use the compiled resources from the Preparation or the Activity 3 Research Resources to guide students to research the amount and types of water. Sample research questions:

- How much of Earth is covered in water?
- How much of the water is salt water? How much of the water is fresh water?
- What types of fresh water and salt water sources exist on Earth?
- Do all rivers have the same amount of water in them? Do all oceans and lakes have the same amount of water? How could that change our class data from Part 1?
- Which sources of fresh water are accessible?
- How much of Earth's water is accessible fresh water?

13 Guide students to record their findings in their Launch Logs and create a digital presentation to share with the class.

14 Allow time for students to share their presentations.

15 Lead a discussion about the presentations.

- How much of Earth is covered in water?
- How much of the water is salt water? How much of the water is fresh water?
- What types of fresh water and salt water sources exist on Earth?
- How do people use water? Why would salt water not help with these tasks or purposes?
- How could the unequal amounts of salt water and fresh water impact people?
- What challenges would a community face if they only had access to salt water?

16 Guide students to view the Distribution of Earth's Water tables to see where Earth's water is located.

**Distribution of Earth's Water**

| Earth's Water | |
|---|---|
| Salt water | 97% |
| Fresh water | 3% |

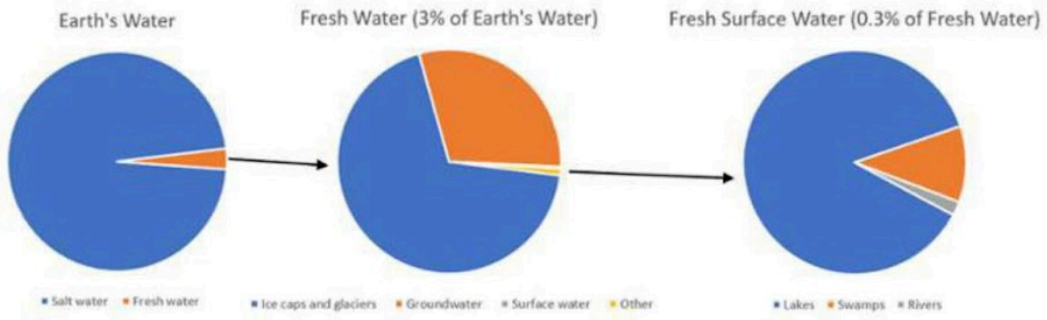
| Fresh Water (3% of Earth's Water) | |
|---|---|
| Ice caps and glaciers | 68.7% |
| Groundwater | 30.1% |
| Surface water | 0.3% |
| Other | 0.9% |

| Fresh Surface Water (0.3% of Fresh Water) | |
|---|---|
| Lakes | 87% |
| Swamps | 11% |
| Rivers | 2% |

17 Lead a discussion about the Distribution of Earth's Water tables.

- How much of Earth's water is fresh water? Since there are 7.7 billion people on Earth, why is fresh water important?
- Where is most of the fresh water located? Are we able to access this water? Why do you think this?
- Where do you think our drinking water comes from? Why do you think this?
- Consider the amount of salt water versus the amount of fresh water on Earth. Why is it important to keep our fresh water clean?

18 Guide students to create three pie charts to represent this data. Sample charts:




19 Reread the true/false statements from Part 1. Guide students to respond with thumbs up or thumbs down to indicate whether they think these statements are true or false. Have students turn and talk with a neighbor to support their claim with evidence.

- Water can be found in rivers. (True)
- Water can be found in lakes. (True)
- Water can be found near Earth's poles. (True)
- Most of the fresh water on Earth is liquid. (False)
- Earth has more land than water. (False)

## Part 3. What Can We Do?

20 Direct students to work with their group to learn more about water. Guide them to view **Why Save?** and **Simple Ways to Save**.

21 Guide students to complete a Think-Pair-Share on the following questions:

- Why is it important to save water?
- What can we do to protect Earth's resources?

> **Note**: Think-Pair-Share is a strategy where students think individually, discuss ideas with a partner, and then share with the whole class. It increases participation and focus.

22 When students explore careers, they can see connections between what they are learning and real-world applications. Guide students to read about Carlton Jones, a biologist at the Environmental Protection Agency.

23 Guide students to answer the Conclusion Questions. Lead a discussion for students to share their thoughts.

## Conclusion Questions Answer Key

1 Why do you think it is important to have usable water?

Student responses should demonstrate an understanding of how water supports life. Responses might include:
I think it is important to have usable water because we use water daily. I need water to drink, brush my teeth, take a shower, and wash my hands. Without water, plants and animals could not survive.

2 Why is usable fresh water such a valuable resource? Use evidence from the activity to support your claim.

Student responses should demonstrate an understanding of the limited amount of usable fresh water. Responses might include:
Usable fresh water is a valuable resource because of the limited amount on Earth. Only 3% of water on Earth is fresh water. Of that, about 30% is in liquid form. Because all life needs water, it is always in demand.

Project

# The Process of Evaporation

Teacher Resources

View Student Course

## EQUIPMENT

The list below is based on a class of 30 students.

| Included in Equipment Kit | Not Included in Equipment Kit | Device Application |
|---|---|---|
| • 300-watt incandescent clamp light<br>• 250-watt incandescent lamp bulb<br>• Petri dishes (16)<br>• Fan with clamp<br>• Dry-erase markers (8) | • PLTW Launch Logs (1 per student)<br>• Digital devices<br>• Pencils or colored pencils for sketching<br>• Water<br>• Terrariums from Activity 2 | • Inkling |

## ESSENTIAL QUESTIONS

EQ

EQ1 How do Earth's major systems interact?
EQ2 Is there enough fresh water on Earth?
EQ3 How can a step-by-step process help you design or improve a solution to a problem?

## LEARNING OBJECTIVES

LO

LO1.2 Use scientific reasoning to ask questions, make observations, and investigate ideas to acquire knowledge and solve problems.
LO2.1 Analyze interactions between two Earth systems at a time.
LO2.2 Understand how the water cycle connects the hydrosphere to the other spheres.
LO4 Understand that science ideas can be used to protect humans, Earth's resources, and its environment.
LO6 Collaborate effectively on a diverse and multidisciplinary team.
LO7 Communicate effectively for specific purposes using the appropriate platform, tool, format, or digital media.
LO8 Practice ethical behavior in all settings.

## KNOWLEDGE AND SKILLS

KS

KS1.2.1 Ask and identify questions to gain knowledge or solve problems.
KS1.2.2 Make observations to draw conclusions of phenomena.
KS1.2.3 Analyze data to look for patterns or to test whether data are consistent with an initial prediction.
KS2.1.1 Identify the hydrosphere, atmosphere, biosphere, and geosphere.
KS2.1.2 Explain how the hydrosphere, biosphere, atmosphere, and geosphere interact.
KS2.2.3 Define each component of the water cycle.
KS4.2 Understand that science findings are limited to questions that can be answered with evidence.
KS6.1 Generate ideas as a team.
KS6.2 Value the contributions of each team member.
KS6.3 Demonstrate collaboration through effective communication.
KS7.1 Document work in an organized notebook.
KS7.2 Explain findings and justify evidence-based conclusions with others.
KS7.3 Present data and information accurately and effectively.
KS8.1 Engage in and maintain positive interactions and relationships with other children and adults.

## Introduction

*Evaporation* is the process of liquid changing into a gas. Evaporation is a critical part of the *water cycle*. It allows water on the surface of Earth to enter the *atmosphere*, where it *condenses* into clouds and falls as *precipitation*.

In this project, students use the *scientific inquiry process* to investigate the process of evaporation. They explore how air movement and heat affect the rate of evaporation.

## Preparation

### Part 1. Evaporation Investigation

1. Become familiar with the vocabulary terms used in this project. Plan how you will help students use these terms as part of their vocabulary.

| | |
|---|---|
| atmosphere | All the gases that surround Earth. |
| biosphere | All the living things on Earth. |
| evaporation | The process of a liquid changing into a gas. |
| geosphere | All the rock, soil, and sediment that make up Earth's land. |
| hydrosphere | All the oceans, rivers, lakes, and water on Earth. |
| scientific inquiry process | A process that scientists use to explore observations and answer questions. |
| system | A group of processes and parts that interact in a connected way. |
| water cycle | The continuous movement of water on, above, and below Earth's surface. |

2. Review the Evidence (Stage 2) and Learning Plan (Stage 3) section of the **Curriculum Framework**. Use this tool to plan how you will formatively and summatively assess students throughout this project.
3. Review the **Additional Instructional Resources**. This list includes books that offer diverse perspectives that can expand student understanding. Using these resources provides a sense of inclusion and belonging, and helps students make connections if the content is new to them.
4. In this project, students use the scientific inquiry process. This process is similar to the design process; however, there are distinct differences. The scientific inquiry process:
   - Is included in PLTW Launch modules to provide exposure and experience for students to think and work scientifically.
   - Is included in the modules whenever students need to collect data and answer testable questions.
   - Helps students learn how to approach a testable question and set up an experiment to collect the necessary data.
5. In Part 1, students investigate two factors that affect evaporation: air movement and heat. It is important that each factor is investigated. You can:
   - Allow students to select the factor to investigate.
   - Assign a specific factor to each group.
6. After students have set up their investigation, leave the petri dishes undisturbed for at least five hours. This time is required to observe the rate of evaporation. Decide how you will facilitate this project over at least two days.

#### Possible Student Misconceptions

- **The water cycle only includes the evaporation of water on Earth into the atmosphere and its return to Earth through condensation**. The sun activates the water cycle, which causes water to evaporate. After water evaporates, it goes through several steps including condensation, sublimation, precipitation, transpiration, becoming runoff, and infiltration. The cycle affects all four of Earth's systems.
- **Water only evaporates from oceans or lakes**. In addition to bodies of water, water can evaporate from plants, animals, puddles, and the ground. Evaporation is the process of a liquid changing to a gas due to an increase in temperature and/or pressure. This can happen anywhere water collects: in puddles, on leaves, and even on you when you get sweaty. Evaporation is a fundamental part of the water cycle and is constantly occurring.
- **Water in an open container is absorbed by the container, disappears, changes into air, or dries up**. Water in an open container evaporates, changing from a liquid to a gas. This gas then becomes part of the atmosphere where it cools and condenses to form clouds. Eventually, these clouds release precipitation which falls back to Earth.

## Procedure

**Time**: 90 Minutes

### Part 1. Evaporation Investigation

1. Direct students to access the project in the student course and have them read the Introduction.
2. Have students prepare their PLTW Launch Logs for the project.
3. Guide students to view their terrarium from Activity 2. Have students make observations and record these in their Launch Logs.
4. Lead a discussion for students to share their observations.

   - What did you observe in the terrarium?
   - How does water get to the plastic wrap? Why do you think that?
   - Describe how water moves through the water cycle in the terrarium. Direct students to use the flashcard example as you review the vocabulary term *water cycle*.
   - How are Earth's systems represented in the terrarium? Direct students to use the flashcard examples as you review the vocabulary terms *system*, *atmosphere*, *biosphere*, *geosphere*, and *hydrosphere*.

5. Ask students what they think scientists do. Discuss that scientists are people who ask questions, make observations, and investigate ideas, to acquire knowledge and/or solve problems. Tell students that they are now going to act as scientists as they investigate evaporation. Direct students to use the flashcard example as you review the vocabulary term *evaporation*.
6. Guide students to view the Scientific Inquiry Process video as an introduction to scientists and the scientific inquiry process.



Scientific Inquiry Process video

7. Lead a discussion about what students learned from the Scientific Inquiry Process video.

   - Why do scientists use the scientific inquiry process? Direct students to access the flashcard example as you review the vocabulary term *scientific inquiry process*.
   - How do you think the scientific inquiry process helps scientists in their work?
   - Why is it important to ask questions as you work through the scientific inquiry process? Why do you think that?

8. Guide students to work with a small group to investigate evaporation.
9. **Ask**
   - Explain to students that scientists ask questions so that they can set up experiments to test and observe what happens.
   - Share the testable questions with the students:
     - How does air movement affect evaporation?
     - How does heat affect evaporation?

     > **Note**: Each group tests only one question. Refer to the Preparation section for suggestions about how to ensure each question is investigated.

   - Have students record their testable question in their Launch Logs.

10 **Predict**
- Have students work with their group to predict an answer to their question.
- Guide them to record their prediction in their Launch Logs.

11 Lead a discussion about the students' predictions.

- How do you think air movement will affect evaporation? Why do you think that?
- How do you think heat will affect air movement? Why do you think that?
- How do you think we can test these questions?

12 **Investigate**
- Explain that students will test their predictions by carrying out an investigation.
- Guide students to complete either the air movement investigation or the heat investigation.

**Air Movement Investigation**
- Fill two petri dishes half full of water.
- Use a dry-erase marker to label one petri dish "Fan" and another petri dish "No Fan". Draw a line at the top of the starting water level on both petri dishes.
- Place one petri dish in the path of the air blown by the fan. The petri dish should have air blown on it, but the air should not force the water out of the dish.
- Place another petri dish outside the path of the air blown by the fan.
- Leave the petri dishes undisturbed for an extended period.

**Heat Investigation**
- Fill two petri dishes half full of water.
- Use a dry-erase marker to label one petri dish "Heat Lamp" and another petri dish "No Heat Lamp". Draw a line at the top of the starting water level on both petri dishes.
- Place one petri dish under the heat lamp.
- Place another petri dish in normal classroom light away from the heat lamp.
- Leave the petri dishes undisturbed for at an extended period.

**Note**: Allow the petri dishes to remain undisturbed for at least five hours. Continue with the project after this period has passed.

## Part 2. Investigation Results

13 **Observe**: Explain to students they will now make observations to see the effect of air movement and heat on evaporation. Guide students to:
- Observe the water that remains in both petri dishes.
- Use a dry-erase marker to draw a line at the top of the ending water level on both petri dishes.
- Compare the petri dishes to observe which one lost the most water.
- Record their findings in their Launch Logs.

14 **Explain**: Guide students to explain the results of their investigation.
- Have students compare their prediction to the actual results and document the findings in their Launch Logs.
- Guide students in an air movement group to pair with students from a heat group. Have each group share their results.

  - How does air movement affect evaporation? Support your answer with evidence.
  - Where have you seen this phenomenon before? Tell me more.
  - How does heat affect evaporation? Support your answer with evidence.
  - Where have you seen this phenomenon before? Tell me more.
  - Were the results of your investigation what you expected? Explain your thinking.
  - Compare the results of both investigation. Does air movement or heat affect the rate of evaporation more? How do you know?

- Lead a discussion about what students learned during their investigations. Ask students to explain their thinking as they share their thoughts. Be sure to address misconceptions.

15 Guide students to answer the Conclusion Questions. Lead a discussion for students to share their thoughts.

## Conclusion Questions Answer Key

1 How could you increase the rate of evaporation in your terrarium? Use evidence from the project to support your thinking.

Student responses should demonstrate an understanding of evaporation. Responses might include:
I could increase the rate of evaporation in my terrarium by placing it under the heat lamp. I know heat speeds up the evaporation process, because more water evaporated in the petri dish under the heat lamp than the petri dish in classroom light. Since the terrarium is a closed system, the fan would not affect it.

2 What happens to water after it evaporates? Support your claim with evidence.

Student responses should demonstrate an understanding of the water cycle. Responses might include:
When the water evaporated, it turned into a gas. This gas will condense in the atmosphere and turn into a cloud. I know this because water moves around Earth in a cycle. The main stages of the water cycle are evaporation, condensation, precipitation, and collection.

Problem

# Clean Enough to Drink

Teacher Resources

View Student Course

## EQUIPMENT

The list below is based on a class of 30 students.

| Included in Equipment Kit | Not Included in Equipment Kit | Device Applications |
|---|---|---|
| • Rubber bands<br>• Duct tape<br>• Aluminum foil<br>• Wax paper<br>• Plastic wrap<br>• Plastic cups<br>• Plastic drainage bins (10)<br>• Funnels (10)<br>• Cotton balls<br>• Paper filters (30)<br>• 300-watt incandescent clamp light<br>• 250-watt incandescent lamp bulb<br>• Petri dishes (24) | • PLTW Launch Logs (1 per student)<br>• Digital devices<br>• Pencils or colored pencils for sketching<br>• Water<br>• Salt<br>• Measuring cups<br>• Empty gallon jugs or containers (2)<br>• Earth materials, such as:<br>  ◦ Sand<br>  ◦ Soil<br>• Terrariums from Activity 2 | • Inkling<br>• Camera<br>• Presentation apps, such as:<br>  ◦ Popplet Lite<br>  ◦ Mindomo<br>  ◦ ShowMe Interactive Whiteboard |

## RESOURCES

R

Research Resources for the Problem

Decision Matrix

Summative Assessment

## ESSENTIAL QUESTIONS

EQ

EQ1 How do Earth's major systems interact?

EQ2 Is there enough fresh water on Earth?

EQ3 How can a step-by-step process help you design or improve a solution to a problem?

## LEARNING OBJECTIVES

LO

LO1.1 Follow a step-by-step method to solve a problem.

LO1.2 Use scientific reasoning to ask questions, make observations, and investigate ideas to acquire knowledge and solve problems.

LO3 Analyze the fractional amounts of salt water, fresh water, and accessible fresh water.

LO4 Understand that science ideas can be used to protect humans, Earth's resources, and its environment.

LO5 Apply mathematical thinking to solve problems.

LO6 Collaborate effectively on a diverse and multidisciplinary team.

LO7 Communicate effectively for specific purposes using the appropriate platform, tool, format, or digital media.

LO8 Practice ethical behavior in all settings.

## KNOWLEDGE AND SKILLS

KS

| | |
|---|---|
| KS1.1.1 | Define a simple design problem reflecting a need or a want. |
| KS1.1.2 | Brainstorm possible solutions to the problem. |
| KS1.1.3 | Make and use a model to test a design, or aspects of a design, and to compare the effectiveness of different design solutions. |
| KS1.1.4 | Evaluate a model solution through observations and/or measurements and consider what revisions to the initial model are needed. |
| KS1.2.1 | Ask and identify questions to gain knowledge or solve problems. |
| KS1.2.2 | Make observations to draw conclusions of phenomena. |
| KS1.2.3 | Analyze data to look for patterns or to test whether data are consistent with an initial prediction. |
| KS3.3 | Explain how humans, animals, and plants need fresh water in order to survive. |
| KS3.5 | Identify ways in which water can be processed to make it usable by humans. |
| KS4.1 | Explore ways to protect Earth's resources and its environment. |
| KS4.2 | Understand that science findings are limited to questions that can be answered with evidence. |
| KS5.1 | Make sense of problems and persevere in solving them. [CCSS.MATH.PRACTICE.MP1] |
| KS5.2 | Reason abstractly and quantitatively. [CCSS.MATH.PRACTICE.MP2] |
| KS6.1 | Generate ideas as a team. |
| KS6.2 | Value the contributions of each team member. |
| KS6.3 | Demonstrate collaboration through effective communication. |
| KS7.1 | Document work in an organized notebook. |
| KS7.2 | Explain findings and justify evidence-based conclusions with others. |
| KS7.3 | Present data and information accurately and effectively. |
| KS8.1 | Engage in and maintain positive interactions and relationships with other children and adults. |

## Introduction

While nearly 70 percent of Earth is covered by water, only 3% of that water is fresh water. The amount of fresh water on Earth has remained relatively constant over time. In fact, the water we drink today was likely around in one form or another when dinosaurs roamed Earth.

However, as Earth's population grows, so does the demand for clean drinking water. Even in regions where water can be found, pollution, bacteria, and animal waste render the water harmful to drink. Producing clean drinking water is a big challenge.

In this problem, students apply their knowledge of the interactions between Earth's systems, the Sun, gravity, and the water cycle to create a method for generating clean drinking water. Students use the *design process* to sketch, build, test, and reflect, on a device that produces clean water.

## Preparation

### Professional Development PD

Before you facilitate the problem, access the **Launchpad** to review:

- Developing Research Skills with Elementary Students
- Thinking Like an Engineer

### Part 1. Contamination

1. Become familiar with the vocabulary terms used in this problem. Plan how you will help students use these terms as part of their vocabulary.

| | |
|---|---|
| biosphere | All the living things on Earth. |
| constraint | A limitation or a restriction. Constraints include limits on time, materials, and size. |
| criteria | Guidelines or rules used to judge or make a decision about something. |
| design process | A step-by-step way to solve problems. |
| gravity | A force that pulls objects toward Earth's center. |
| hydrosphere | All the oceans, rivers, lakes, and water on Earth. |
| water cycle | The continuous movement of water on, above, and below Earth's surface. |

2. Review the Evidence (Stage 2) and Learning Plan (Stage 3) section of the **Curriculum Framework**. Use this tool to plan how you will formatively and summatively assess students throughout this problem.
3. Review the **Additional Instructional Resources**. This list includes books that offer diverse perspectives that can expand student understanding. Using these resources provides a sense of inclusion and belonging, and helps students make connections if the content is new to them.
4. Preview the Water Contamination resource in the student course to become familiar with the content. Review the discussion questions in the Procedure.

### Part 2. The Design Process

1. Use the Family Letter in the Introduction to the Module to ask families for donations of clean jars, clean bottles, or aluminum pans.
2. During the Explore step of the design process, students research different water purification methods to learn how others have tried to solve a similar problem. Review the resources listed in the **Research Resources for the Problem** document and plan how you will facilitate this section. Consider the following options:
   - Gather books about water contamination, water filtration, and water purification.
   - Develop a list of websites, articles, or other materials for students to explore.
3. Prepare two contaminated water samples for the class. To create the dirty water, mix 1 cup of sand or soil with 12 cups of water. To create the salt water, mix ½ cup of salt with 12 cups of water.
4. Each group tests only one sample of water. Be sure at least one group tests the dirty water and at least one group tests the salt water.
5. As students work through the design process to develop a solution, use the Earth's Water and Interconnected Systems Rubric to assess their demonstration of learning. A printable version of the rubric is accessible in the Resources section on the **Summative Assessment** page. Use the rubric as a guide throughout the process of solving the problem.
6. Become familiar with the **Decision Matrix**. A decision matrix is a tool that allows students to rate the designs based on the criteria. If desired, you can print a copy of the decision matrix for each student to complete and glue in their Launch Log.

### Possible Student Misconceptions

- **Groundwater is always pure because soil filters out all impurities**. Harmful bacteria in water can be filtered out by soil, but many chemical pollutants are not changed and remain in the water. These chemical pollutants stay in the water and seep into the ground which damages the soil. When the water evaporates into the atmosphere, it causes the atmosphere to become polluted. This in turn causes chemicals to be in the water that falls back to Earth.
- **Pouring a small amount of waste on the ground will not cause a problem**. Groundwater contamination occurs when human-made products, such as gasoline, oil, road salts, and chemicals, get into the groundwater and cause it to become unsafe and unfit for human use. Even small amounts of hazardous substances disposed of improperly can cause groundwater pollution.

## Procedure

**Time**: 180 Minutes

### Part 1. Contamination

1. Direct students to access the problem in the student course and have them read the Introduction.
2. Have students prepare their PLTW Launch Logs for the problem.
3. Guide students to view their terrarium from Activity 2. Have students make observations and record them in their Launch Logs.
4. Lead a discussion for students to share their observations.

   - What did you observe in the terrarium?
   - How has the terrarium changed over time? Explain your thinking.
   - Is the water in the terrarium fresh water or salt water? How do you know?

5. Direct students to read the resource on water contamination in the student course.
6. Lead a discussion to review the challenges of accessing clean water.

   - What causes water to become contaminated? Direct students to use the flashcard example as you review the vocabulary term *hydrosphere*.
   - How can water become contaminated from the biosphere? Direct students to use the flashcard example as you review the vocabulary term *biosphere*.
   - What other contaminants can cause water to be unclean?
   - How does contaminated water affect the biosphere?
   - Why is it important to be able to access clean water? Why do you think this?
   - How does the water cycle play a role in contaminating or cleaning water? Direct students to use the flashcard example as you review the vocabulary term *water cycle*.
   - Could we use the power of the Sun, gravity, and/or the water cycle to produce clean water for people to drink? Direct students to use the flashcard example as you review the vocabulary term *gravity*.

7. Guide students to read An Environmental Turning Point in the student course. Prompt students to share their thoughts with a partner or in small groups.

   The EPA protects our air, water, soil, and people. Why is it important to have an agency dedicated to this goal?

**Want to Know More?**

If you or your students want to learn more about environmental events that led to the formation of the Environmental Protection Agency, consider exploring the EPA photojournalism project, Documerica. You can access photographs and descriptions of the project in the National Archives.

### Part 2. The Design Process

8. Direct students to access the flashcard example as you introduce the vocabulary term *design process*.

- Ask students to share examples of how they have used a step-by-step process to complete a task. Examples include:
  - Getting ready for school
  - Brushing their teeth
  - Solving a math problem
  - Making a snack
- Explain to the students that they are going to use the same steps that engineers use to design new items and improve existing items.

9 Present the Design Process video as an introduction to engineers and the design process.




Design Process video

10 Lead a discussion about what students learned from the Design Process video.

- Why do engineers use the design process?
- How do you think the design process helps engineers in their work?
- Why is it important to ask questions as you work through the design process? Why do you think that?
- In the video, we learned that it is important to understand the problem before looking for a solution. Have you ever identified a problem and then looked for a solution? Allow students to share their thoughts.

11 For the problem, the PLTW Launch Log has a guided section titled, "Solving the Problem." Guide students to locate and preview this section in their Launch Logs. Students record notes, sketches, and ideas for each step of the design process. Remind students that it is important to include details that provide evidence for their thinking throughout the process.

12 Guide students to follow the design process to sketch, build, test, and reflect on a device that produces clean water.

13 The first step in the design process is **Ask**.

- Remind students about the Ask step of the design process. In this step, students ask questions to make sure they have a clear understanding of the problem and the criteria and constraints for their design.
- Guide a discussion where students ask questions to gather information that will help them define the problem.
- With support and guidance, the students define the problem, "How can I design a device that produces clean water?"
- Explain that when engineers solve problems, they have to follow the *criteria* and *constraints* for the solution. Use the flashcard examples as you introduce or clarify the vocabulary terms *criteria* and *constraint*.
- Introduce the criteria and constraints of the design.

| Criteria | Constraints |
|---|---|
| • The group must design, build, and test a device to produce clean water from one of two samples of contaminated water: dirty water or salt water.<br>• The device must collect as much water as possible in the clean collection container.<br>• The collected water must be visibly less cloudy than the original dirty water, or the collected water must have less salt than the original water. | • Time<br>• Available materials |

- Guide the students in a discussion to consider the problem, criteria, and constraints.
- Guide students to record their responses in the Ask step of their Launch Logs.
- Have students complete the self-reflection at the end of the Ask section in their Launch Logs. Guide students to circle one statement in each row. Assess student understanding and record comments as needed.

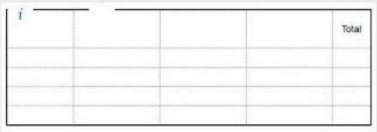
> **Note**: At the end of each stage of the design process, students complete a self-reflection. This self-reflection is intended for students to provide honest feedback about their skills during each stage. They are not expected to be "advanced" in all areas all the time. Explain to students that this self-reflection is intended to help them grow as problem-solvers.

14 The second step in the design process is **Explore**.

- Guide students to research how others have tried to solve a similar problem. Encourage students to research a variety of water purification methods, such as physical, biological, chemical, and solar. See **Research Resources for the Problem** for research options.
- Have students record their research findings in the Explore section of their Launch Logs.
- Guide students to brainstorm several ideas that may solve the problem. Students may use the skills and knowledge they gained from the activities and project in this module, as well as information they gathered from their research.
- Show students what materials are available. You can display items on a table for students to observe, or you may hold up the items in front of the class one at a time.
- Guide students to decide which materials they will use to design their model.
- Direct students to record ideas for their solution in the Explore section of their Launch Logs.
- Guide students to share their initial ideas with their group. Encourage them to add any new ideas by writing or sketching in their Launch Logs.
- Have students complete the self-reflection at the end of the Explore section in their Launch Logs. Assess student understanding and record comments as needed.

15 The third step in the design process is **Model**.

- Introduce a decision matrix as a way to decide on the best design. Using the **Decision Matrix**, students rate each group member's design based on a 0–1 scale for each category. If the design does not meet the criterion in a category, it receives a 0 in that category. If the design does meet the criterion, it receives a 1. The design with the highest total score offers the best solution from the group.

> **Note**: Students may use the decision matrix in their Launch Logs or the copy you provide. If they use the one in their Launch Logs, they need to complete the column and row headers as shown.
>
> 
> 

- Guide students to use the chosen design to create their water purification device.
- To facilitate creation of the water purification devices, circle around the room and assess student progress. Ask students to share their ideas and their thinking with you as they work.
- Guide students to add a drawing or a photograph of their model in the corresponding section of their Launch Logs.
- Have students complete the self-reflection at the end of the Model section in their Launch Logs. Assess student understanding and record comments as needed.

16 The fourth step in the design process is **Evaluate**.

- Explain to students how they will conduct a fair test to determine how well their model solves the design problem. Use the following steps:
  - Create a chart to record the results of the test.
  - Obtain a sample of dirty water or salt water.

> **Note**: Be sure to shake the water samples well to distribute the sediment and salt.

  - Observe the water sample and record observations on the chart.
  - Take a photograph of the water sample.
  - Place the water sample in the device and allow it to purify.

> **Note**: Some devices take longer than others to purify the water. If the devices require several hours, guide students to place them in the designated testing area.

  - Observe the purified water and record the observations on the chart.
  - Take a photograph of the purified water.
  - For the groups with the salt water sample, place a small amount of purified water in a petri dish. Set the petri dish under the heat lamp for the water to evaporate. Observe what remains in the petri dish and record that in the chart.
- Encourage students to discuss the results to decide whether their model solved the problem.
- Guide students to reflect on strengths and weaknesses of their designs and record them in the corresponding section of their Launch Logs.

- Have students complete the self-reflection at the end of the Evaluate section in their Launch Logs. Assess student understanding and record comments as needed.

17 The fifth step in the design process is **Explain**.

- Guide students to create a presentation using ShowMe Interactive Whiteboard, Popplet Lite, or Mindomo. The presentation should include all aspects of the design process, such as:
  - Photographs of the design sketches and research findings
  - Photograph of the decision matrix
  - Photographs of the water purification device before, during, and after testing
  - Photographs of the comparisons between before and after water samples.
  - Strengths and weaknesses of the design
  - Ways to improve the design
- Provide time for students to share their presentations.
- After all presentations, lead a discussion about the features, strengths, and weaknesses of the different water purification designs.

  - Which type of design seemed to be the most successful at cleaning the water? Why do you think this?
  - Would the designs you made be effective at cleaning water contaminated by chemicals or bacteria? Why do you think that? What would you need to design a device that could effectively remove these contaminants from water?
  - If you could choose a different type of material for your design, what would you choose? Why do you think that material would work better?
  - If you could improve anything else about your design, what would you improve? Why would you improve that aspect?
  - How can the design process be used to improve people's lives?
  - Sometimes things don't always work out the way we think they will. What can you learn when things don't work out?
  - How did you contribute to the success of your team's design?
  - How did your team members contribute to the success of the design?

- Guide students to complete the Explain section of their Launch Logs. Have students describe their evaluation of how their design solved (or did not solve) the problem.
- Have students complete the self-reflection at the end of the Explain section. Then assess student understanding and record comments as needed.

18 Guide students to answer the Conclusion Questions. Lead a discussion for students to share their thoughts.

19 Direct students to complete the Earth's Water and Interconnected Systems Check for Understanding. You can access a printable version of this assessment in the Resources section of the **Summative Assessment** page.

## Conclusion Questions Answer Key

1 How does the lack of clean water affect people on a global level? Support your answer with evidence.

Student responses should demonstrate an understanding of the importance of clean water. Responses might include:
Water is essential for everyone in the world. People need water to drink, wash their hands, bathe, and grow crops. Without clean water, people would die from illnesses and dehydration.

2 Now that you have learned about the importance of clean water, what will you do in your everyday life to reduce your daily water consumption?

Student responses should demonstrate an understanding of the importance of clean water. Responses might include:
There are two easy things I can do to reduce my daily water consumption.
First, I can turn the water off when I brush my teeth. I should only turn the faucet on when I need water.
Second, I can take shorter showers. I can set a timer so I know how much time I spend in the shower, and then I can aim to reduce this time.

Introduction to the Module

# Ecosystems: Flow of Matter and Energy

Teacher Resources



**Distance Learning Support**

For information about PLTW's distance learning support and online learning guides, jump to Distance Learning Support in **PLTW Launch Module-specific PD Resources**.

For distance learning support for facilitating this module, jump to **Distance Learning Support: Ecosystems: Flow of Matter and Energy Teacher Guide**.

## PREFACE

**Time**: 10 instructional hours

In this module, students learn about Earth's ecosystems and how energy flows from the Sun to plants, and from plants to animals. Students create a model to describe photosynthesis and explain how energy from the Sun is introduced into an ecosystem. Over the course of several days, students conduct an investigation into what plants need to grow. By its completion, students are able to use evidence to defend the claim that plants get the materials they need for growth mainly from air and water.

Students learn about the different roles organisms play in an ecosystem and participate in an interactive game that demonstrates how energy flows through an ecosystem. Next, they explore an online simulation and learn different ways that an ecosystem can become unbalanced. Finally, students use the design process to research and develop an action plan to protect plants and animals in a specific ecosystem that has become unbalanced due to human activity.

## RESOURCES

R

Device Specifications

Application List

## Preparation

Are you ready to teach this module? Hold it right there! As you may remember from PLTW Launch Classroom Teacher Training, to create an engaging learning experience for your students, planning is essential.

This Teacher Guide includes resources you need for both planning and facilitation. The following outline lists the general resources designed to help you prepare to teach this module to your students.

Curriculum Framework and Connections to Standards

Professional Development

Community

Rostering Students

Family and Community Relationships

PLTW Launch Logs

Developing Vocabulary

Icon Legend

Additional Instructional Resources

Curriculum Revisions

Introduction Story

# The Coyote Mystery

Teacher Resources

View Student Course

RESOURCE

R

Introduction Story: The Coyote Mystery

**Time**: 20 Minutes

## Introduction

To set the stage for learning, guide students to read the Introduction Story: *The Coyote Mystery*, a fictional story that introduces the problem. You may print the story if needed.

1. Introduce students to the student course and assist them with the log-in process on a digital device. For the rest of the module, students will access the curriculum in the student course.
2. Guide students to access the Introduction Story: *The Coyote Mystery*. Students can read or listen to the story using audio in small groups. Alternatively, you may read the story aloud as a class.
3. Use the guiding questions within the story to engage students in thinking about ideas and concepts throughout the module. Use this time of discussion to uncover what your students already know about the concepts, what they are curious about, and what misconceptions they have. Consider how this formative assessment of students can guide you as you facilitate the activities, project, and problem in this module. To set the purpose for the learning experiences to come, it's also important to guide students to identify the problem.
4. Throughout the module, students can reread the story to remind themselves of the problem they will be solving.

Activity 1

# Energy from the Sun

Teacher Resources

View Student Course

## EQUIPMENT

The list below is based on a class of 30 students.

| Included in the Equipment Kit | Not Included in Equipment Kit | Device Applications |
|---|---|---|
| • Pipe cleaners<br>• Pom-poms<br>• Tacky glue<br>• Masking tape<br>• Colored paper | • PLTW Launch Logs (1 per student)<br>• Digital devices<br>• Pencils or colored pencils for sketching<br>• Chart paper<br>• Markers<br>• Optional materials for the photosynthesis models:<br>  ◦ Colorful beads<br>  ◦ Poster board | • Inkling<br>• Camera |

## RESOURCE

R

Photosynthesis Key Element cards

## ESSENTIAL QUESTIONS

EQ

EQ1 How do matter and energy flow through an ecosystem?
EQ2 How does a change in an ecosystem affect its balance?
EQ3 How can a step-by-step process help you design or improve a solution to a problem?

## LEARNING OBJECTIVES

LO

LO1.2 Use scientific reasoning to ask questions, make observations, and investigate ideas to make sense of phenomena and solve problems.
LO2.1 Analyze how plants grow.
LO4 Understand that science ideas can be used to protect humans, Earth's resources, and its environment.
LO5.1 Apply mathematical thinking to solve problems.
LO6 Collaborate effectively on a diverse and multidisciplinary team.
LO7 Communicate effectively for specific purposes using the appropriate platform, tool, format, or digital media.
LO8 Practice ethical behavior in all settings.

## KNOWLEDGE AND SKILLS

KS

- KS1.2.2 Make observations to draw conclusions of phenomena.
- KS1.2.3 Analyze data to look for patterns or to test whether data are consistent with an initial prediction.
- KS2.1.1 Understand that plants get the material they need to grow primarily from air and water.
- KS2.1.2 Provide evidence to defend how plants use air and water to get the materials they need to survive.
- KS2.1.3 Develop a basic understanding of photosynthesis.
- KS4.2 Understand that science findings are limited to questions that can be answered with evidence.
- KS5.1.1 Reason abstractly and quantitatively. [CCSS.MATH.PRACTICE.MP2]
- KS5.1.3 Use appropriate tools strategically. [CCSS.MATH.PRACTICE.MP5]
- KS6.1 Generate ideas as a team.
- KS6.2 Value the contributions of each team member.
- KS6.3 Demonstrate collaboration through effective communication.
- KS7.1 Document work in an organized notebook.
- KS7.2 Explain findings and justify evidence-based conclusions with others.
- KS7.3 Present data and information accurately and effectively.
- KS8.1 Engage in and maintain positive interactions and relationships with other children and adults.

## Introduction

Like all living organisms, plants need food, water, and air to survive. Plants create their own food using energy from the Sun through the process of *photosynthesis*. Photosynthesis happens in a specialized cell found in plants called a *chloroplast*, and uses sunlight, water, and *carbon dioxide* to create *glucose*, which plants use to grow. Students learn about this process and create a model that represents how plants provided with sun, air, and water have everything they need to grow.

## Preparation

### Professional Development PD

Before you facilitate Activity 1, access the **Ecosystems: Flow of Matter and Energy Module-specific PD Resources** to review:

- Building Your Understanding: Photosynthesis
- Building Your Understanding: Pollination and Pollinators Part 1
- Building Your Understanding: Pollination and Pollinators Part 2

### Activity 1

1. Become familiar with the vocabulary terms used in this activity. Plan how you will help students use these terms as part of their vocabulary.

| | |
|---|---|
| carbon dioxide | A gas found in the atmosphere that plants absorb to create glucose during photosynthesis. |
| chloroplast | A green cell found in plants that absorbs light to make glucose during photosynthesis. |
| glucose | A type of sugar; the main source of plant food for growth. |
| matter | An element, material, or substance that has mass and takes up space. In an ecosystem, biotic and abiotic matter are recycled over and over. |
| photosynthesis | The process plants use to make glucose using sunlight, air, and water. |
| solar energy | Radiation from the Sun that is needed for organisms to survive and grow. |
| stomata | A tiny opening on plant leaves through which air enters. |

2. Review the Evidence (Stage 2) and Learning Plan (Stage 3) section of the **Curriculum Framework**. Use this tool to plan how you will formatively and summatively assess students throughout this activity.
3. Determine ways you can support the development of transportable skills in this module. Examples include calling out ways students demonstrate the skills, asking questions that allow students to reflect on their development of the skills, and integrating books listed in the Transportable Skills: Literature Connections resource.
4. Review the **Additional Instructional Resources**. This list includes books that offer diverse perspectives that can expand student understanding. Using these resources provides a sense of inclusion and belonging, and helps students make connections if the content is new to them.
5. To access a printable version of the Launch Log, go to **PLTW Launch Logs**.
6. Before you begin Activity 1, read the **Introduction Story: The Coyote Mystery** with students.
7. Preview the **Photosynthesis** interactive experience to become familiar with its content. Review the discussion questions in the Procedure.
8. Decide how you will divide your class into eight groups to develop their photosynthesis model.
9. Print one set of Photosynthesis Key Element cards for each group.
10. Place equipment on a table for students to access materials while creating their photosynthesis models. This includes the photosynthesis cards, pipe cleaners, pom-poms, glue, and any other optional materials you choose to give students. If you do not have a designated supply table, you can divide the materials and place them at each table.

#### Possible Student Misconceptions

- **Plants breathe by inhaling carbon dioxide and exhaling oxygen**. Plants do not breathe. They absorb air through the stomata (pores) in their leaves.
- **The "air" that we all breathe is just oxygen**. Oxygen is only one of many gases that are found in the air we breathe. Almost 80% of the air around us is nitrogen, and many other substances, including carbon dioxide, are in the air we breathe. We absorb the oxygen into our body, and breathe out the other substances. Plants, on the other hand, absorb carbon dioxide and release oxygen.

## Procedure

**Time**: 90 Minutes

1. Direct students to access Activity 1 in the student course and have them read the Introduction.

2. Students use PLTW Launch Logs to keep a record of their work as they progress through the module. Distribute a Grades 3–5 Launch Log to each student. In the notebook, they may take notes as they research, create sketches, and answer conclusion questions.
3. Have students prepare their PLTW Launch Logs for Activity 1.
4. Activate prior knowledge by asking students to share what they know and want to know about plants.

   - What are some plants that you have seen or learned about?
   - What do you want to know about plants?

5. Introduce the **Photosynthesis** interactive experience. In this experience, students are able tp manipulate pages and click hot spots to learn about the components of photosynthesis.
6. Direct students to work with a small group to work through all the features in the interactive experience. Students take notes in their Launch Logs about the roles of the Sun, water, oxygen, carbon dioxide, chloroplasts, and glucose in photosynthesis.
7. Introduce how photosynthesis benefits humans.
   - Living things depend on glucose for energy. Humans and other animals cannot produce glucose on their own, so they rely on glucose from the foods they eat. Plants create glucose during photosynthesis.
   - Humans and other animals use the oxygen produced during photosynthesis to breathe. The health of plants is essential to our survival.
8. Lead students in a discussion about photosynthesis.

   - What roles do the Sun, water, oxygen, carbon dioxide, chloroplasts, and glucose play in photosynthesis? Direct students to the flashcard examples as you review the vocabulary terms *photosynthesis*, *carbon dioxide*, *chloroplast*, and *glucose*.
   - All plants are made of matter. How do you think matter flows through the process of photosynthesis? Direct students to the flashcard example as you introduce the vocabulary term *matter*.

9. Tell students that they will work with a small group to create a model of photosynthesis with a variety of materials. Explain to them that a successful model shows all six key elements of photosynthesis, labeled using the Photosynthesis Key Element cards, and includes a written and/or verbal explanation of the process of photosynthesis.
10. Show students what materials are available. You may display the materials on a table for students to observe, or you may hold them up in front of the class.
11. Direct groups to plan their model. Have students sketch their model in their Launch Logs, including labels of the materials they will need.
12. After their plan is complete, have students collect their materials and begin building their models.
13. Circulate around the groups as they work and ask them to explain how their model represents the steps of photosynthesis.

    - What gas is the plant absorbing?
    - What gas is the plant releasing?
    - How does a plant use carbon dioxide and water to make glucose?
    - What item on your model represents the source of energy?
    - Why do we create and share models?

14. When students are finished, have one student from each group stay with their model to present it as the rest of the class completes a gallery walk. Ask teammates to trade places every two or three minutes, so every group member gets a chance to present.
15. Guide students to answer the Conclusion Questions. Lead a discussion for students to share their thoughts.

## Conclusion Questions Answer Key

**Note**: Conclusion Questions offer an opportunity for formative assessment. You may use them as a whole-class discussion or you may have students record ideas in their Launch Logs.

1. Based on your understanding of photosynthesis, support an argument that plants need air to grow. Use evidence from this activity to explain your thinking.

   Student responses should demonstrate an understanding of photosynthesis. Responses might include:
   Plants need air to grow. When they go through photosynthesis, plants use their different structures to absorb and transport air. They convert carbon dioxide from the air into oxygen. Going through this process helps the plants to grow and survive.

2. As living things, what do you and a plant have in common? What is one difference?

Student responses should demonstrate an understanding of the need for air, water, and/or food. Responses might include:
Both plants and I need air to breathe, water, and food. Plants make their own food through photosynthesis, but I eat plants and other animals for food.

Activity 2

# What Do Plants Need to Grow?

Teacher Resources

View Student Course

## EQUIPMENT

This list is based on a class of 30 students.

| Included in Equipment Kit | Not Included in Equipment Kit | Device Applications |
|---|---|---|
| • Seed sprouter inner trays (10)<br>• Seed sprouter bottom trays (10)<br>• Alfalfa seeds<br>• Plastic wrap<br>• Seed paper<br>• 2-cup measuring cup<br>• Digital scale | • PLTW Launch Logs (1 per student)<br>• Digital devices<br>• Pencils or colored pencils for sketching<br>• Chart paper<br>• Markers<br>• Permanent marker<br>• Bowl<br>• Tablespoon<br>• Water<br>• Optional: Grid chart paper (1 piece) | • Inkling<br>• Camera<br>• ShowMe Interactive Whiteboard |

## RESOURCE

R

Observation Charts Worksheet

## ESSENTIAL QUESTIONS

EQ

EQ1 How do matter and energy flow through an ecosystem?
EQ2 How does a change in an ecosystem affect its balance?
EQ3 How can a step-by-step process help you design or improve a solution to a problem?

## LEARNING OBJECTIVES

LO

LO1.2 Use scientific reasoning to ask questions, make observations, and investigate ideas to make sense of phenomena and solve problems.
LO2.1 Analyze how plants grow.
LO4 Understand that science ideas can be used to protect humans, Earth's resources, and its environment.
LO5.1 Communicate effectively for specific purposes and settings.
LO5.2 Apply geometry to solve problems.
LO6 Collaborate effectively on a diverse and multidisciplinary team.
LO7 Communicate effectively for specific purposes using the appropriate platform, tool, format, or digital media.
LO8 Practice ethical behavior in all settings.

## KNOWLEDGE AND SKILLS

KS

| | |
|---|---|
| KS1.2.1 | Ask and identify questions to gain knowledge or solve problems. |
| KS1.2.2 | Make observations to draw conclusions of phenomena. |
| KS1.2.3 | Analyze data to look for patterns or to test whether data are consistent with an initial prediction. |
| KS2.1.1 | Understand that plants get the material they need to grow primarily from air and water. |
| KS2.1.2 | Provide evidence to defend how plants use air and water to get the materials they need to survive. |
| KS4.2 | Understand that science findings are limited to questions that can be answered with evidence. |
| KS5.1.1 | Reason abstractly and quantitatively. [CCSS.MATH.PRACTICE.MP2] |
| KS5.1.2 | Model with mathematics. [CCSS.MATH.PRACTICE.MP4] |
| KS5.2.1 | Represent problems by graphing points in the first quadrant of the coordinate plane, and interpret coordinate values of points in the context of the situation. [CCSS.MATH.5.G.A.2] |
| KS6.1 | Generate ideas as a team. |
| KS6.2 | Value the contributions of each team member. |
| KS6.3 | Demonstrate collaboration through effective communication. |
| KS7.1 | Document work in an organized notebook. |
| KS7.2 | Explain findings and justify evidence-based conclusions with others. |
| KS7.3 | Present data and information accurately and effectively. |
| KS8.1 | Engage in and maintain positive interactions and relationships with other children and adults. |

## Introduction

To grow, plants primarily need air and water, with energy from the Sun. Some plants grow without soil and even without roots. Students use the *scientific inquiry process* to conduct an investigation about what plants need to grow. Students set up seed sprouters, water the plants, weigh them, and observe their growth. The data students collect will provide evidence to explain that plants primarily use air and water to get the materials they need to live.

## Preparation

### Part 1. Day 1

1. Become familiar with the vocabulary terms used in this activity. Plan how you will help students use these words as part of their vocabulary.

| | |
|---|---|
| matter | An element, material, or substance that has mass and takes up space. In an ecosystem, biotic and abiotic matter are recycled over and over. |
| scientific inquiry process | A process that scientists use to explore observations and answer questions. |

2. Review the Evidence (Stage 2) and Learning Plan (Stage 3) section of the **Curriculum Framework**. Use this tool to plan how you will formatively and summatively assess students throughout this activity.
3. Review the **Additional Instructional Resources**. This list includes books that offer diverse perspectives that can expand student understanding. Using these resources provides a sense of inclusion and belonging, and helps students make connections if the content is new to them.
4. In Activity 2, students use the Scientific Inquiry Process. This process is similar to the design process, but there are distinct differences. The Scientific Inquiry Process:
   - Is brought into PLTW Launch modules to provide exposure and experience for students to think and work scientifically.
   - Is included in the modules whenever students need to collect data and answer testable questions.
   - Helps students learn how to approach a testable question and set up an experiment to collect the necessary data.

   > **Note**: The complete Scientific Inquiry Process will span about five days. The Observe step should take place over three to five days, which is typically how long it takes for the alfalfa seeds to grow.
5. Use a piece of chart paper titled "Ask" to document this step of the scientific inquiry process. Another option is to create the chart using the ShowMe Interactive Whiteboard app and project the chart for students to view.

| Ask |
|---|
| |

6. Determine a method for dividing students into eight groups.
7. Print one Observation Charts Worksheet for each student. This worksheet is found in Resources. Preview the worksheet to become familiar with the way students will organize their data throughout the activity.
8. For at least eight hours, soak about 1 tablespoon of alfalfa seeds per group in a bowl filled with water. Drain and rinse the seeds before beginning Activity 2. Leave at least one tablespoon of alfalfa seeds dry to investigate whether the seeds can grow without water.
9. Prepare the seed sprouter trays.
   - Label the outside of the bottom trays with group numbers 1–8 using masking tape and a permanent marker.
   - Label one bottom tray with "No Water". You will use this tray as a model for collecting data throughout the investigation. Additionally, this tray will be used so students can conclude whether the seeds can grow without water.
10. Gather your materials for Part 1. On a designated supply table, place the following:
    - Soaked alfalfa seeds
    - Prepared seed sprouter trays
    - Plastic wrap
    - Seed paper
    - Digital scale
    - 2-cup measuring cup
    - Tablespoon
    - Water ready for each group to use
11. Use a piece of chart paper to create a table that documents the growth of seeds without water. Another option is to create the chart using the ShowMe Interactive Whiteboard app and project the chart for students to view.

| No Water | | | | |
|---|---|---|---|---|
| Date | Mass (g) | Increase/Decrease in Mass | Observations | Photograph (✔) |
| Inner tray and seed paper | | N/A | N/A | N/A |
| Day 1: _____ | | N/A | | |
| Day 2: _____ | | | | |
| Day 3: _____ | | | | |
| Day 4: _____ | | | | |
| Day 5: _____ | | | | |

12. Decide where you will store the seed sprouter trays. They seeds should not be placed in direct sunlight, so near a window is not recommended.
13. The water in the trays should be changed at least once per day. Students need daily access to their plants. If you do not see students on a daily basis, work with other teachers or administrators to allow students to visit your classroom outside of their normally scheduled class time to make observations.

## Part 2. Days 2–5

Have the seed sprouters, digital scale, and 2-cup measuring cup ready for students to use.

### Possible Student Misconceptions

- **Plants cannot survive without soil**. Some plants grow in soil-free environments. Plants can absorb water and nutrients from soil, but they can also get these from the air or from the water if they are water-based plants.
- **Plants take in all substances they need to grow through their roots**. Carbon dioxide in the air is the main building block that makes up the huge trunks, heavy branches, and leaves of trees and other plants. Plants take in air through their leaves. Some plants also absorb water and nutrients through their leaves.
- **Plants need to eat fertilizer to grow**. Plants do not "eat" because they make their own food from light, water, and air through the process of photosynthesis. "Plant food" (fertilizer) can provide additional minerals and nutrients for plants, but it is not necessary for growth.

# Procedure

**Time**: 60 Minutes

## Part 1. Day 1

1. Direct students to access Activity 2 in the student course and have them read the Introduction.
2. Have students prepare their PLTW Launch Logs for Activity 2.
3. Review what students learned in Activity 1.

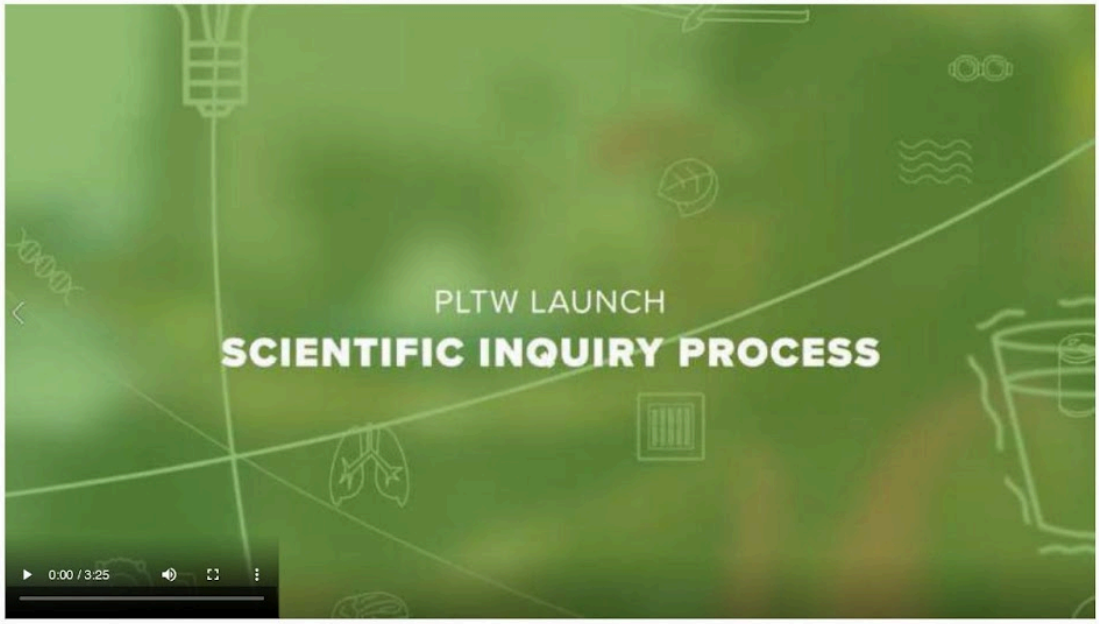
   - How do plants create their own food? Direct students to the flashcard example as you review the vocabulary term *photosynthesis*.
   - What role do the Sun, water, oxygen, carbon dioxide, chloroplasts, and glucose play in photosynthesis? Direct students to the flashcard examples as you review the vocabulary terms *carbon dioxide*, *chloroplast*, and *glucose*.

4. Introduce the seed sprouter investigation. In this investigation, students will determine what the most important things are that plants need to grow.

   Based on your knowledge of photosynthesis, where do you think plants acquire their material for growth? Explain your reasoning. Use the flashcard example to review the vocabulary term *matter*.

5. Ask students what they think scientists do. Discuss that scientists are people who ask questions, make observations, and investigate ideas, to acquire knowledge and/or solve problems. Tell students that they are going to act as scientists as they investigate plants.

6 Guide students to view the Scientific Inquiry Process video as an introduction to scientists and the scientific inquiry process.




Scientific Inquiry Process video

7 Lead a discussion about what students learned from the Scientific Inquiry Process video.

- Why do scientists use the scientific inquiry process? Direct students to access the flashcard example as you review the vocabulary term *scientific inquiry process*.
- How do you think the scientific inquiry process helps scientists in their work?
- Why is it important to ask questions as you work through the scientific inquiry process? Why do you think that?
- What makes a question a testable question?

8 **Ask:** Guide students to ask questions so they can set up experiments to test and observe what happens.

- Direct students to work in small groups to brainstorm testable questions about plants. Have students record their questions in their Launch Logs.
- Have each group share some of their questions with the class. Write down their questions on your "Ask" chart or using the ShowMe Interactive Whiteboard app.
- Put a star by questions on the chart related to plant growth.
- Tell students the testable question for this investigation is: Do plants need water to grow?

9 **Predict:** Guide students to make a prediction to answer the testable question.

- Direct students to record their prediction in their Launch Logs about whether or not plants need water to grow. Have them provide an explanation for their thinking.
- Remind students that their predictions should be based on their prior knowledge about plants gained from past experiences and knowledge.
- Lead a discussion about the students' predictions.

- Do you think plants need water to grow? Why do you think this?
- How do you think we can test your prediction?

10 **Investigate**: Explain that students will test their predictions by carrying out an investigation.

- Explain that for the purposes of this investigation, an increase in a plant's mass is an indication of growth.
- Explain to the class that as part of the investigation, they will collect data to document whether their seeds are growing, and by how much.
- Explain that all groups will test whether their seeds grow with water. You will also test whether seeds grow without water, and use your tray to model how to collect data.
- Hand out an Observation Charts Worksheet to each student.
- Hand out one seed sprouter inner tray, one bottom tray, and one piece of seed paper for each small group of students to examine. Direct students to record their group number on their worksheet.
- Lead a discussion about the seed sprouter trays and seed paper.

- Do you think we can we use this tray and seed paper to plant our alfalfa seeds? Why or why not?
- What features does it have to help plants grow?
- How will we know if the plants grow?

- Using the digital scale, model how to weigh the mass in grams (g) of one inner tray and seed paper. Record the mass on your chart paper titled "No Water". Have students record this measurement on their worksheets.
- Direct groups to weigh their inner trays and seed paper, and record the mass on their worksheets.
- Model how to place one tablespoon of dry alfalfa seeds on top, spread out evenly across the tray.
- Give one tablespoon of soaked alfalfa seeds to each small group. Direct students to place their seeds on top of their seed paper.
- Model how to weigh the mass of the tray with the seeds. Then, subtract the mass of the tray to find the mass of just the seeds, and record this as the Day 1 data on your chart paper. Have students record this on their worksheets.
- Direct students to do the same with their trays and seeds, and record this on their worksheets.
- Have students decide who in their group will complete each of the following jobs each day:
  - Add water to the bottom tray
  - Weigh the inner tray with seeds and sprouts, and subtract the mass of the empty tray
  - Take photographs
  - Write observations about the sprouts

> **Note**: These jobs should be rotated daily, so students complete each of them throughout the investigation.

11 **Observe:** Direct each group to observe and photograph their seeds using their assigned jobs.
- Model how to observe and photograph the seeds using your tray without water. Record the data in the Day 1 row of your chart paper. Direct students to record this data on their worksheets. Observations should include:
  - Color
  - Size
- Have students record the data for their seeds in the Day 1 row on their worksheets.
- Direct students to take a photograph of their seeds.

12 Model how to secure a piece of plastic wrap on top of your inner tray. Direct students to do the same.

13 Guide groups to store their trays in your designated location.

14 Direct the students who are watering the bottom trays to do so at this time. The water should be changed at least once per day. Students should add two cups of water to the bottom tray, so the seeds on the inner tray are not touching the water. Explain that the seeds do not need to be placed in water, because the water in the bottom tray will evaporate and water the seeds.

15 Lead a discussion about what students have learned so far in the investigation.

- How will you determine whether your plant is growing?
- How will we determine the answer to our testable question: Do plants need water to grow?

## Part 2. Days 2–5

> **Note**: These steps should be repeated daily, for three or more days.

16 **Observe:** Direct each group to weigh, observe, and photograph their trays using their assigned jobs.
- Model how to weigh, observe, and photograph the seeds using your tray without water.
  - Remove the plastic wrap.
  - Weigh only the inner tray with seed paper and seeds.
  - Subtract the original mass of the empty tray found on Day 1 from the current mass to get the difference. This is the mass of the plants.
  - Record this on the chart paper titled "No Water," and have students record the data on their worksheets.
- Direct students to weigh, observe, and photograph their seeds.
- Have students record their data in the chart on their worksheets. To observe, students can look and carefully touch the seeds and sprouts. Observations should include:
  - Color of sprouts
  - Rigidness of sprouts
  - Height of sprouts

17 Place all inner trays on a table where the class can view the plants. Ask students to share their observations with you.

18 Direct students to compare the growth of plants with and without water. Lead a discussion about student observations of whether water correlates to more or less plant growth so far.

19 Lead a discussion about their predictions.

- What prediction did you make in your Launch Log at the start of the investigation?
- What have you observed so far about what plants need to grow?
- Based on these observations, do you anticipate that your prediction may be incorrect? Is it okay to have incorrect predictions?

**Note**: Take this opportunity to reinforce that incorrect predictions are a part of the scientific inquiry process.

20 Direct students to cover their inner tray with plastic wrap, and place their seed sprouter trays back in their previous locations.

## Part 3. Conclusion

21 **Observe**: Model how to graph the data from their observations, using the data from your No Water chart. Use a piece of grid chart paper or the ShowMe Interactive Whiteboard app to create the graph.

- Create a title
- Draw x- and y-axes on a grid
- Label the x-axis with the dates of the observations
- Label the y-axis with the mass of the alfalfa sprouts
- Use the data from the No Water chart to create a line plot

22 Direct students to work with their groups to graph their own data from their alfalfa sprouts in their Launch Logs. The graphs should include labeled x- and y-axes and all of their data points.

23 **Explain**: Guide students to make a digital presentation using the ShowMe Interactive Whiteboard app. Their presentation should:

- Make a claim that answers the question, "What do plants need to grow?"
- Explain the claim using the knowledge, data, evidence, and observations that were collected during Activities 1 and 2.
- Include daily photographs and a graph.

Based on this investigation, students should conclude that plants need water to grow. Additionally, students should apply their knowledge from Activity 1 that demonstrates plants use light energy and air to conduct photosynthesis, which leads to growth as well. During the Explain step, students should therefore emphasize that plant matter comes mostly from air and water, not soil.

24 Have students share their presentations with another group. Have the groups ask follow-up questions to each other.

- How do you know?
- What is your evidence?

25 Lead a discussion about the investigation.

- Apply what you have learned about photosynthesis to your seed sprouter investigation. How do you know photosynthesis is or is not occurring? Why do you think that?

  We know that photosynthesis is occurring because of the color and rigidness of the alfalfa sprouts. The green color comes from chlorophyll, which is one of the key elements of photosynthesis. The rigidness and growth of the bean sprouts is evidence that the plants are converting water and carbon dioxide from the air into glucose.

- Where do plants acquire their material for growth? Use evidence from the investigation to explain.

  Plant matter comes mostly from air and water.

26 Guide students to answer the Conclusion Questions. Lead a discussion for students to share their thoughts.

## Conclusion Questions Answer Key

1 Throughout the first two activities, you learned about what plants need to grow. Do you think animals need the same things to grow? Why or why not?

Student responses should demonstrate an understanding that plant matter comes mostly from air and water. Responses might include:

I know that plants need air and water to grow. I think this is the same for animals, too. All living things have basic needs to survive. Humans are animals, and I know that if I do not have air and water, then I cannot grow and survive.

2 What other questions do you have about the world around you? How could you apply the scientific inquiry process to learn more about that topic?

Student responses will vary. Student responses should demonstrate an understanding of the Ask, Predict, and Investigate steps of the scientific inquiry process to answer a new question.

Activity 3

# Energy Through Food Webs

Teacher Resources

View Student Course

## EQUIPMENT

The list below is based on a class of 30 students.

| Included in Equipment Kit | Not Included in Equipment Kit | Device Applications |
|---|---|---|
| • *Pass the Energy, Please* by Barbara Shaw McKinney<br>• Tokens<br>• Labels<br>• Resealable plastic bags | • PLTW Launch Logs (1 per student)<br>• Digital devices<br>• Pencils or colored pencils for sketching<br>• Chart paper<br>• Markers<br>• Bucket, bin, or hat labeled "Soil" | • Inkling<br>• ShowMe Interactive Whiteboard |

## RESOURCE

R

Food Web Game

## ESSENTIAL QUESTIONS

EQ

EQ1 How do matter and energy flow through an ecosystem?
EQ2 How does a change in an ecosystem affect its balance?
EQ3 How can a step-by-step process help you design or improve a solution to a problem?

## LEARNING OBJECTIVES

LO

LO1.2 Use scientific reasoning to ask questions, make observations, and investigate ideas to make sense of phenomena and solve problems.
LO2.1 Analyze how plants grow.
LO2.2 Describe how matter and energy flow among living things.
LO5.1 Apply mathematical thinking to solve problems.
LO6 Collaborate effectively on a diverse and multi-disciplinary team.
LO7 Communicate effectively for specific purposes using the appropriate platform, tool, format, or digital media.
LO8 Practice ethical behavior in all settings.

## KNOWLEDGE AND SKILLS

KS

| | |
|---|---|
| KS1.2.2 | Make observations to draw conclusions of phenomena. |
| KS1.2.3 | Analyze data to look for patterns or to test whether data are consistent with an initial prediction. |
| KS2.1.1 | Understand that plants get the material they need to grow primarily from air and water. |
| KS2.1.2 | Provide evidence to defend how plants use air and water to get the materials they need to survive. |
| KS2.1.3 | Develop a basic understanding of photosynthesis. |
| KS2.2.1 | Understand that all living things use energy which is stored or transferred between organisms. |
| KS2.2.2 | Describe how an animal's food can be traced back to plants, which can be traced back to the Sun. |
| KS2.2.3 | Explain that animals use the energy from food for body repair, growth, movement, and maintaining warmth. |
| KS2.2.4 | Model how energy and matter flow between organisms and the environment. |
| KS5.1.1 | Reason abstractly and quantitatively. [CCSS.MATH.PRACTICE.MP2] |
| KS5.1.2 | Model with mathematics. [CCSS.MATH.PRACTICE.MP4] |
| KS5.1.3 | Use appropriate tools strategically. [CCSS.MATH.PRACTICE.MP5] |
| KS6.1 | Generate ideas as a team. |
| KS6.2 | Value the contributions of each team member. |
| KS6.3 | Demonstrate collaboration through effective communication. |
| KS7.1 | Document work in an organized notebook. |
| KS7.2 | Explain findings and justify evidence-based conclusions with others. |
| KS7.3 | Present data and information accurately and effectively. |
| KS8.1 | Engage in and maintain positive interactions and relationships with other children and adults. |

## Part 1. Introduction to Food Webs

1. Direct students to access Activity 3 in the student course and have them read the Introduction.
2. Have students prepare their PLTW Launch Logs for Activity 3.
3. Lead a discussion to review students' background knowledge.

- How do plants use air, light, and water to make food? Direct students to access the flashcard example as you review the vocabulary terms *photosynthesis*, *carbon dioxide*, and *glucose*.
- How do you get energy to grow, move, and play?

4. Read the book *Pass the Energy, Please* aloud for students. You may choose to use a document viewer to project an image of the book.
5. Lead a discussion about the book.

- What are some examples of organisms that make their own energy from the Sun? What are they called? Direct students to access the flashcard example as you review the vocabulary terms *energy* and *producer*.
- What are some herbivores, and what do they eat? Direct students to access the flashcard example as you review the vocabulary term *herbivore*.
- What are some carnivores, and what do they eat? Direct students to access the flashcard example as you review the vocabulary term *carnivore*.
- What are some omnivores, and what do they eat? Direct students to access the flashcard example as you review the vocabulary term *omnivore*.
- Examine the roles of insects. Give examples of insects that are consumers and examples of insects that are decomposers. Direct students to access the flashcard examples as you review the vocabulary terms *consumer* and *decomposer*.
- How can an ecosystem become unbalanced? Direct students to access the flashcard examples as you review the vocabulary terms *ecosystem* and *unbalanced ecosystem*.
- How is energy passed through a food chain? Use evidence from the book to explain. Direct students to access the flashcard example as you review the vocabulary term *food chain*.
- How does this connect to your life?

6. Guide students to access and explore the food web graphic. Direct students to access the flashcard example to introduce the vocabulary term *food web*.
7. Direct students to read the list of claims in the student course with a small group. Then in their Launch Logs, have students complete the following:
   - Use the food web diagram to support each claim with evidence.
   - Record their observations using descriptions, sketches, and notes.
   - Label their claim statements and evidence statements.

Student responses should demonstrate an understanding of how energy flows through the ecosystem and the roles of producers, consumers, and decomposers. Responses might include:

- **Evidence 1**: Plants are at the bottom of the food web. They rely on solar radiation for energy. So, the Sun gives energy to the base of the food web, which is then passed on to other consumers when they eat the plants.
- **Evidence 2**: The squirrel, grasshopper, rabbit, and deer all eat producers, making them herbivores. The hawk, shrew, snake, and mountain lion eat other animals, making them carnivores. The bird eats both producers and animals, making it an omnivore.
- **Evidence 3**: The snake eats both shrews and rabbits.
- **Evidence 4**: The decomposers, like worms and mushrooms, are at the bottom of the food web near the soil. This is the base of the food web. These decomposers break down every living organism in this food web.

8. Lead a discussion about the claims and evidence statements.

- What patterns did you notice in the food web graphic?
- What evidence do you have for your thinking?
- Why is it important to support your claims with evidence?

## Part 2. Food Web Game

9. Introduce the Food Web Game. See **Food Web Game** for step-by-step directions. Explain that students will act as parts of an ecosystem to demonstrate how energy transfers from one organism to another. Each student will have a role, and students will exchange tokens that represent energy.
10. Play the Food Web Game to see how energy transfers from one organism to the next.
11. Lead a discussion about the game.

## Introduction

The Sun is the source of all *energy* in an *ecosystem*. This energy is transferred between plants and animals in an ecosystem, until it finally ends up in the soil beneath your feet.

In this activity, students will learn about this energy transfer as they listen to a read aloud. Then, they will use a *food web* to provide evidence for a series of claims. Finally, the class will play a food web game where you will act as the Sun, and your class are the organisms in an ecosystem. You will pass your energy to the organisms through the food web, until this energy reaches the soil.

## Preparation

### Professional Development PD

Before you facilitate Activity 3, access the **Ecosystems: Flow of Matter and Energy Module-specific PD Resources** to review Building Your Understanding: Ecosystems.

### Part 1. Introduction to Food Webs

1. Become familiar with the vocabulary terms used in this activity. Plan how you will help students use these words as part of their vocabulary.

| | |
|---|---|
| carnivore | An animal that eats other animals. |
| consumer | An organism that consumes, or eats, a plant or animal for energy. |
| decomposer | An organism that breaks down dead plants or animals and returns nutrients to the soil. |
| ecosystem | A community of organisms that interact with each other and their environment. |
| energy | The ability to do work. The Sun is the primary source of energy in an ecosystem. |
| food chain | A diagram showing the direct path of energy from producers to consumers. |
| food web | A diagram showing interconnecting food chains that illustrate the flow of energy through an ecosystem. |
| herbivore | An animal that eats only plants. |
| omnivore | An animal that eats both plants and animals. |
| photosynthesis | The process plants use to make glucose using sunlight, air, and water. |
| producer | A plant that creates energy through photosynthesis. |

2. Review the Evidence (Stage 2) and Learning Plan (Stage 3) section of the **Curriculum Framework**. Use this tool to plan how you will formatively and summatively assess students throughout this activity.
3. Review the **Additional Instructional Resources**. This list includes books that offer diverse perspectives that can expand student understanding. Using these resources provides a sense of inclusion and belonging, and helps students make connections if the content is new to them.
4. Read the book *Pass the Energy, Please* to become familiar with the content. Review the discussion questions in the Procedure.

### Part 2. Food Web Game

1. Review the directions and complete the preparation for the **Food Web Game**.
2. Decide how to separate students into small groups for a discussion before the game.

#### Possible Student Misconceptions

- **Food webs are the same as food chains**. Food webs show the flow of energy within an entire ecosystem. Food chains follow just one path for an animal to find food. Food webs illustrate multiple food chains, and show the complex set of relationships in an ecosystem.
- **Decomposers create energy to feed plants**. Decomposers are another step in passing energy from one organism to another through the food web. Decomposers, such as worms and bacteria, eat dead organisms. As they digest dead organisms, they release nutrients back into the soil. Plants can then absorb the nutrients to help them grow. People participate in this process when they compost food scraps.

## Procedure

**Time**: 180 Minutes

- Where did the energy you consumed originally come from?

  Energy originally came from the Sun in the form of solar energy. It was converted to glucose in the producers.

- Which type of organism was most plentiful?

  The most plentiful organisms were the producers.

- What happened to energy as it moved throughout the food web?

  The amount of energy transferred between organisms decreased as it traveled through the food web.

- Why was some energy eaten by the worms?

  The worms represent decomposers. They break down some of the energy and nutrients and return them to the soil.

- Each time an animal was killed, why did the consumer only get some of the energy, rather than all of it?

  Throughout the animal's life, some of the energy was used up by the organism to maintain body temperature, grow, repair, and reproduce.

- What happened to the energy eaten by the worms? Did it go directly to the grass?

  The energy and nutrients are not given directly to the grass. Instead, they are released into the soil. Soil is not essential for plants to grow, but it provides nutrients for most producers on land. This helps energy enter back into the food web.

- What are the limitations of the game?

  - In a real food web, there are many more animals than are represented in the game.
  - There are many more varieties of decomposers than were represented in the game, and they exist in greater numbers.
  - Consumption in a food web is not split into rounds. Everything happens continuously.

- In what ways would human life be different without the food web process? Why do you think that?

  Without the food web, all living things including humans would not receive the Sun's energy that is passed through the web.

12 Direct students to draw a model of the food web from the game in their Launch Logs.

13 Guide students to answer the Conclusion Questions. Lead a discussion for students to share their thoughts.

## Conclusion Questions Answer Key

1 What was your role in the Food Web Game? Where did you get your energy? Where did your energy go? If you were not consumed, where would your energy go at the end of your life? Be sure to use specific vocabulary terms in your response.

Student responses should demonstrate an understanding of the energy flow in a food web and use the vocabulary terms producer, consumer, herbivore, or carnivore. Responses should indicate that some of the energy could not be consumed because it was used for growth, repair, and reproduction. Responses might include:
In the Food Web Game, I was a worm. Worms are decomposers. I got my energy from any organism that was sitting down, or had died. The energy I used went toward growth, repair, and reproduction. The energy I didn't use went into the soil, and would also go to the soil at the end of my life.

2 What would happen to an ecosystem if the Sun disappeared?

Student responses should demonstrate an understanding of the fundamental role the Sun plays in providing energy to the ecosystem. Responses might include:
All the energy in the ecosystem comes from the Sun, so all the producers/plants would die. When the plants die, herbivores' food sources would be gone, so they would also die. When the herbivores die, so would all the predators/carnivores. If the Sun were to disappear, it would create a domino effect, and all energy would stop flowing through the ecosystem.

Project

# Balanced and Unbalanced Ecosystems

Teacher Resources

View Student Course

## EQUIPMENT

The list below is based on a class of 30 students.

| Not Included in Equipment Kit | Device Applications |
|---|---|
| • PLTW Launch Logs (1 per student)<br>• Digital devices<br>• Pencils or colored pencils for sketching | • Inkling<br>• The Habitable Planet: Ecology Lab, provided with permission from Annenberg Learner |

## RESOURCE

R

Simulation Worksheet

## ESSENTIAL QUESTIONS

EQ

EQ1 How do matter and energy flow through an ecosystem?
EQ2 How does a change in an ecosystem affect its balance?
EQ3 How can a step-by-step process help you design or improve a solution to a problem?

## LEARNING OBJECTIVES

LO

LO2.2 Describe how matter and energy flow among living things.
LO3 Evaluate the delicate balance of interactions within an ecosystem.
LO4 Understand that science ideas can be used to protect humans, Earth's resources, and its environment.
LO6 Collaborate effectively on a diverse and multi-disciplinary team.
LO7 Communicate effectively for specific purposes using the appropriate platform, tool, format, or digital media.
LO8 Practice ethical behavior in all settings.

## KNOWLEDGE AND SKILLS

KS

KS2.2.1 Understand that all living things use energy which is stored or transferred between organisms.
KS2.2.3 Explain that animals use the energy from food for body repair, growth, movement, and maintaining warmth.
KS2.2.4 Model how energy and matter flow between organisms and the environment.
KS3.1 Identify the components of an ecosystem.
KS3.2 Explain how matter and energy flow within an ecosystem.
KS3.3 Understand that producers, consumers, and decomposers play an important role within an ecosystem.
KS3.4 Understand that a healthy ecosystem is one in which multiple organisms can meet their needs in a relatively stable web of life.
KS3.5 Explain how ecosystems can be balanced and unbalanced by human behavior.
KS4.1 Explore ways to protect Earth's resources and its environment.
KS4.2 Understand that science findings are limited to questions that can be answered with evidence.
KS6.1 Generate ideas as a team.
KS6.2 Value the contributions of each team member.
KS6.3 Demonstrate collaboration through effective communication.
KS7.1 Document work in an organized notebook.
KS7.2 Explain findings and justify evidence-based conclusions with others.
KS7.3 Present data and information accurately and effectively.
KS6.1 Engage in and maintain positive interactions and relationships with other children and adults.

# Introduction

# Preparation

In this project, students continue their study of *food webs* as they learn about *ecosystems*. They learn that an ecosystem is a community of living and nonliving things that interact as a system. An ecosystem can become unbalanced easily if a new species is introduced or humans impact the system. This can cause species' populations to increase or decrease dramatically. Students apply what they have learned to try to *balance* an ecosystem in an online simulation.

## Professional Development PD

Before you facilitate the Project, access the **Ecosystems: Flow of Matter and Energy Module-specific Resources** to review Building Your Understanding: Computer Models and Simulations.

## Part 1. Introduction to Ecosystems

1. Become familiar with the vocabulary terms used in this project. Plan how you will help students use these words as part of their vocabulary.

| | |
|---|---|
| abiotic factors | Nonliving components of an ecosystem, such as water, sunlight, and oxygen. |
| balanced ecosystem | An ecosystem in which many organisms can meet their needs. |
| biome | A large area, or region of the world, described by its plants, animals, soil, and climate. |
| biotic factors | Living components of an ecosystem, such as plants and animals. |
| carnivore | An animal that eats other animals. |
| climate | The average weather conditions in a particular region over a period of years. |
| competition | When two or more organisms try to use the same limited resource. |
| ecologist | A scientist who studies the relationship between organisms and their environments. |
| ecology | The study of how living and nonliving things are connected to each other in their natural environment. |
| ecosystem | A community of organisms that interact with each other and their environment. |
| food web | A diagram showing interconnecting food chains that illustrate the flow of energy through an ecosystem. |
| herbivore | An animal that eats only plants. |
| keystone species | A group of organisms that have a big effect on the balance of an ecosystem. |
| matter | An element, material, or substance that has mass and takes up space. In an ecosystem, biotic and abiotic matter are recycled over and over. |
| natural environment | All our surroundings. This includes the air, land, water, plants and animals. |
| organism | A living thing. |
| unbalanced ecosystem | An ecosystem in which many organisms cannot meet their needs. |

2. Review the Evidence (Stage 2) and Learning Plan (Stage 3) section of the **Curriculum Framework**. Use this tool to plan how you will formatively and summatively assess students throughout this project.
3. Review the **Additional Instructional Resources**. This list includes books that offer diverse perspectives that can expand student understanding. Using these resources provides a sense of inclusion and belonging, and helps students make connections if the content is new to them.
4. To become familiar with the content, preview the student resource, "What Are Ecosystems?" Review the discussion questions provided in the Procedure.

## Part 2. Simulation

1. Test the link to the **The Habitable Planet: Ecology Lab** simulation.

> The *Ecology Lab* simulation allows students to build their own ecosystem by exploring the effects of the interrelationships between top predators, omnivores, herbivores, and plants.
>
> For more information about how to use the simulation, access learner.org. For each simulation, you can access teacher tips and additional language translations.

To begin, explore the different features available in the simulation on your own for 5–10 minutes. Then, to explore the impact of varying *biotic factors*, or plants and animals, on an ecosystem, complete the following steps.

- Select The Producers lesson. Your goal for this lesson is to get two plants to coexist.
- Click two plants to use in the simulation.
- Click the rabbit and assign it a food source. You should see that the rabbits can only eat plants. Complete this step for any other organisms you choose to include in the simulation.
- Click Run. The graph indicates the population of each organism. You can hover over the graph lines to see the population totals for each day.
- Click Reset. Adjust the organisms you included and/or their food sources. Click Run, and observe how the populations change.
- Were you able to get at least two plants to coexist? If not, adjust the simulation, and try again.
- Select the Food Web lesson. Your goal for this lesson is to see how large you can make your food web and still have all of the organisms survive through the end of the simulation.
- Choose all organisms and assign each at least one food source. Click Run, and observe how the populations change using the graph.
- Were you able to have every organism survive? If not, adjust the simulation, and try again.

2. Print one Simulation Worksheet for each student. This worksheet is found in Resources. Preview the worksheet to become familiar with the instructions and data charts students will use.
3. Preview the optional Historical Highlight. Consider selecting an invasive species in your area to learn more about and share what you learn with your students, or have your students research an assigned invasive species.

## Part 3. Abiotic Factors in an Ecosystem

1. Decide how you want to divide the class into small groups.
2. Prepare a piece of chart paper with two columns labeled "Organism" and "Impact". An option is to create the chart using the ShowMe Interactive Whiteboard app and project the chart for students to see.

| Organism | Impact<br>*How might flooding affect these organisms?* |
|---|---|
| Cattail grass | |
| Fish | |
| Deer | |
| Humans | |

### Possible Student Misconceptions

- **Species live together in ecosystems because they have learned how to get along**. Within an ecosystem, species compete for resources and feed on one another. Species coexist in the same ecosystem because of the compatible adaptations they have made over time due to their changing environment, and to one another.
- **If a species' population size increases or decreases, it may not affect an ecosystem because some organisms are not important**. All organisms are important within an ecosystem. If a species' population size increases or decreases, it may not affect all other species equally, but it will affect the ecosystem as a whole.
- **Plants cannot defend themselves against herbivores**. Some plants have adapted to discourage animals from eating them. For example, some plants grow hair, thorns, or waxy leaves that make them hard to digest. There are plants that contain chemicals that are poisonous to some animals.

# Procedure

**Time**: 90 Minutes

## Part 1. Introduction to Ecosystems

1. Direct students to access the project in the student course and have them read the Introduction.
2. Have students prepare their PLTW Launch Logs for the project.
3. Lead a discussion to review Activity 3.

- What was your role in the food web game? Where did you get your energy from? Direct students to access the flashcard example as you review the vocabulary term *food web*.
- Where did all of the energy in the food web come from originally?

4. Direct students to read the resource "What Are Ecosystems?" to learn information about balanced and unbalanced ecosystems. Direct students to answer the questions found in the resource in their Launch Logs while they read.

**CAREER CONNECTIONS**

In "What Are Ecosystems?" students read about Dr. Caroline Ridley, an ecologist with the Environmental Protection Agency. When students explore careers, they can see connections between what they are learning and real-world applications.

5 Lead a discussion about the resource.

- How can abiotic factors in an ecosystem help support life for the biotic factors in an ecosystem?
- What can cause ecosystems to become unbalanced?
- What are some actions humans can take to protect ecosystems?

## Part 2. Simulation

6 Tell students they get to act like ecologists as they explore the effects of adding or removing species in an ecosystem. Explain that they will get the chance to build their own ecosystem in an online simulation.

7 Have students open the The Habitable Planet: Ecology Lab simulation on their digital devices. Hand out a Simulation Worksheet to each student.

8 Show students how to navigate the simulation.

- Explain to students that the food web is represented at the top left-hand side of the window. When starting out, only two plants should be activated.
- Show how to select which organisms would be active in a simulation.
- Show the graph at the bottom of the page. Explain that the x-axis represents the number of days in the simulation, and the y-axis represents the population of animals within the ecosystem.

9 Direct students to work on both challenges in a small group, by following the steps on the Simulation Worksheet.

10 Lead a discussion about the simulation to help students conclude that a healthy ecosystem is one in which multiple organisms can meet their needs in a relatively stable web of life.

- What conclusions can you draw about what creates a balanced ecosystem?

  A balanced ecosystem is one where most organisms can meet their needs. This would mean that most animals have access to enough food. Additionally, the populations of different organisms are relatively stable.

- How did you arrive at that conclusion?
- Do some species have a greater influence on the success of the ecosystem? Why or why not?

  Some species might have a greater impact on the ecosystem if they are a food source for several animals. For example, mice are a food source for snakes, hawks, and owls. If the population of mice decreased, it would affect several species.

- What role do humans play in balancing ecosystems?

  Humans can help balance ecosystems by learning more about the organisms within them. Humans can be mindful of development and create plans that protect native species.

- How does human activity lead to unbalanced ecosystems?

  Humans can cause unbalanced ecosystems by impacting the populations of animals. Animal populations may decrease when habitats are destroyed, food sources are impacted, or when animals are hunted.

- Imagine that humans release many new species of animals into the ecosystem from another habitat. What do you think would happen?

  The new species might cause an imbalance in the ecosystem because they might introduce more competition for a food source.

**HISTORICAL HIGHLIGHT**

Consider searching for and sharing one example of an invasive species with your students. The USDA National Invasive Species Information Center (NISIC) provides **Invasive Species Profiles**, which include when the species was first reported, its native habitat, how the species was introduced, and species impact. Use the table to select a species present in or near your area to learn more about.

| Invasive Species | Impacted Region |
|---|---|
| Africanized honeybee | Southwestern U.S. |
| Asian carp | Mississippi, Ohio, Missouri, Illinois Rivers |
| Beach vitex | Coastal Southeastern U.S. and Coastal New York |
| Brown marmorated stink bug | Eastern and Far Western U.S. |
| Chinese privet | Southern and South Central U.S. |
| Emerald ash borer | Eastern and Central U.S. |
| English ivy | Western and Eastern U.S. |
| Garlic mustard | Midwest and Northeastern U.S. |
| Japanese spiraea | North Central, Midwest, and Eastern U.S. |
| Kudzu | Southeastern U.S. |
| Wild boar | Southern U.S. |
| Zebra mussel | North Central and Northeastern U.S. |

## Part 3. Abiotic Factors in an Ecosystem

11. Explain to students that the simulation showed how changes in biotic factors can cause an ecosystem to become unbalanced. In this part, students will explore how changes in abiotic factors can impact the rest of the ecosystem.
12. Guide students to access the illustration of the river ecosystem. Have students work with a small group to look at the photo and find examples of biotic and abiotic parts of the ecosystem. Students document their findings in their Launch Logs, then share out to the whole group.
13. Direct students to discuss in their small groups how each of the abiotic factors impact an ecosystem, then share out whole group.

- Amount of water: Flooding, drought
- Soil: Erosion, soil pollution
- Air: Pollution

14. Have students read the news announcement located in the student course about a change in a river ecosystem.
15. Direct students to discuss the announcement in their small groups.
16. Use the model you prepared to guide students to create a table in the ShowMe Interactive Whiteboard app. Within the chart, small groups predict how different biotic factors might be affected by flooding.
17. Have students complete a gallery walk to evaluate the other charts.
18. Guide students to answer the Conclusion Questions. Lead a discussion for students to share their thoughts.

## Conclusion Questions Answer Key

1. Consider this statement: Each part of the ecosystem is as important as another. Based on what you have learned about ecosystems, do you agree or disagree? Explain your reasoning.

Student responses should demonstrate an understanding of keystone species and competition. Responses might include:
I disagree because some species are better at getting resources like water, sunlight, or food. They can out-compete other species and the species would die. Keystone species are those that are critical to keeping the ecosystem in balance, so they are more important than others.

2. What role(s) do humans play in ecosystems? Do you think humans lead to ecosystems becoming more or less balanced?

Student responses should demonstrate an understanding of competition and how humans affect biotic and abiotic factors. Responses might include:
Humans lead to ecosystems becoming less balanced because we use up a lot of the resources like cutting down trees and drinking or polluting water. It is harder for other organisms to get the resources they need to survive.

Problem

# Save the Ecosystem!

Teacher Resources

View Student Course

## EQUIPMENT

The list below is based on a class of 30 students.

| Not Included in Equipment Kit | Device Applications |
|---|---|
| • PLTW Launch Logs (1 per student)<br>• Digital devices<br>• Pencils or colored pencils for sketching<br>• Chart paper<br>• Markers | • Inkling<br>• Digital product apps, such as:<br>  ◦ Popplet Lite<br>  ◦ Mindomo<br>  ◦ ShowMe Interactive Whiteboard<br>  ◦ Quik<br>  ◦ TwistedWave<br>  ◦ Video function on device |

## RESOURCES

R

Research Resources

Decision Matrix

Summative Assessment

## ESSENTIAL QUESTIONS

EQ

EQ1 How do matter and energy flow through an ecosystem?
EQ2 How does a change in an ecosystem affect its balance?
EQ3 How can a step-by-step process help you design or improve a solution to a problem?

## LEARNING OBJECTIVES

LO

LO1.1 Follow a step-by-step method to solve a problem.
LO1.2 Use scientific reasoning to ask questions, make observations, and investigate ideas to make sense of phenomena and solve problems.
LO2.2 Describe how matter and energy flow among living things.
LO3 Evaluate the delicate balance of interactions within an ecosystem.
LO4 Understand that science ideas can be used to protect humans, Earth's resources, and its environment.
LO6 Collaborate effectively on a diverse and multidisciplinary team.
LO7 Communicate effectively for specific purposes using the appropriate platform, tool, format, or digital media.
LO8 Practice ethical behavior in all settings.

| KNOWLEDGE AND SKILLS | KS |
|---|---|
| KS1.1.1 | Define a simple design problem reflecting a need or a want. |
| KS1.1.2 | Brainstorm possible solutions to the problem. |
| KS1.1.3 | Use evidence to compare and explain the effectiveness of different design solutions. |
| KS1.1.4 | Evaluate a model solution through observations and/or measurements and consider what revisions to the initial model are needed. |
| KS1.2.1 | Ask and identify questions to gain knowledge or solve problems. |
| KS1.2.2 | Make observations to draw conclusions of phenomena. |
| KS1.2.3 | Analyze data to look for patterns or to test whether data are consistent with an initial prediction. |
| KS2.2.1 | Understand that all living things use energy which is stored or transferred between organisms. |
| KS2.2.2 | Describe how an animal's food can be traced back to plants, which can be traced back to the Sun. |
| KS3.1 | Identify the components of an ecosystem. |
| KS3.2 | Explain how matter and energy flow within an ecosystem. |
| KS3.3 | Understand that producers, consumers, and decomposers play an important role within an ecosystem. |
| KS3.4 | Understand that a healthy ecosystem is one in which multiple organisms can meet their needs in a relatively stable web of life. |
| KS3.5 | Explain how ecosystems can be balanced and unbalanced by human behavior. |
| KS4.1 | Explore ways to protect Earth's resources and its environment. |
| KS4.2 | Understand that science findings are limited to questions that can be answered with evidence. |
| KS6.1 | Generate ideas as a team. |
| KS6.2 | Value the contributions of each team member. |
| KS6.3 | Demonstrate collaboration through effective communication. |
| KS7.1 | Document work in an organized notebook. |
| KS7.2 | Explain findings and justify evidence-based conclusions with others. |
| KS7.3 | Present data and information accurately and effectively. |
| KS8.1 | Engage in and maintain positive interactions and relationships with other children and adults. |

## Introduction

In this problem, students work in small groups to develop an *action plan* to protect the plants and animals in an *ecosystem* that has been *unbalanced* by human behavior. Students use the *design process* to develop their plan. They conduct research and present their plan as a podcast, video blog, or other digital media format.

## Preparation

### Professional Development

Before you facilitate the problem, review the professional development resources.

- Access the **Launchpad** to review:
  - Thinking Like an Engineer
  - Developing Research Skills with Elementary Students
  - Integrating Technology and Promoting Online Safety
  - Staying Safe and Secure! Interactive Experience
- Access the **Ecosystems: Flow of Matter and Energy Module-specific Resources** to review Designing an Action Plan.

### Part 1. Local Ecosystems

1. Become familiar with the vocabulary terms used in this problem. Plan how you will help students use these words as part of their vocabulary.

| | |
|---|---|
| abiotic factors | Nonliving components of an ecosystem, such as water, sunlight, and oxygen. |
| action plan | A detailed strategy that defines the steps to reach a goal. |
| biotic factors | Living components of an ecosystem, such as plants and animals. |
| consequence | Something that happens as a result of a particular action. |
| constraint | A limitation or a restriction. Constraints can be limits on time, materials, and size. |
| consumer | An organism that consumes, or eats, a plant or animal for energy. |
| criteria | Guidelines or rules used to judge or make a decision about something. |
| decomposer | An organism that breaks down dead plants or animals and returns nutrients to the soil. |
| design process | A step-by-step way to solve problems. |
| ecosystem | A community of organisms that interact with each other and their environment. |
| producer | A plant that creates energy through photosynthesis. |
| unbalanced ecosystem | An ecosystem in which many organisms cannot meet their needs. |

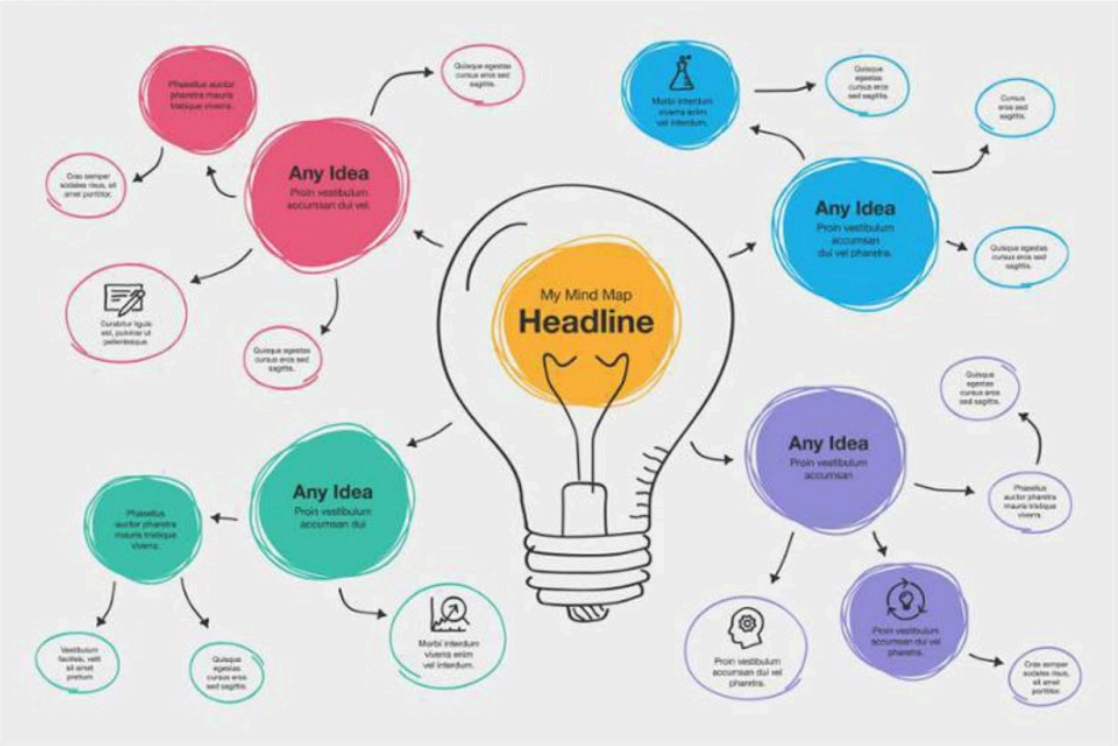
2. Review the Evidence (Stage 2) and Learning Plan (Stage 3) section of the **Curriculum Framework**. Use this tool to plan how you will formatively and summatively assess students throughout this problem.
3. Review the **Additional Instructional Resources**. This list includes books that offer diverse perspectives that can expand student understanding. Using these resources provides a sense of inclusion and belonging, and helps students make connections if the content is new to them.
4. Gather newspaper articles, magazines, or photographs about local ecosystems, changes in species populations, and/or the human impact on local ecosystems.
5. Consider reaching out to a local environmental agency or group about local ecosystems and human impact. Schedule a time for representatives from the group to visit your classroom to provide local information and to provide a career or volunteer connection for students.
6. Prepare a piece of chart paper titled "Local Ecosystems". Another option is to create the chart using the ShowMe Interactive Whiteboard app and project the chart for students to view.

| Local Ecosystems |
|---|
| |

7. As students work through the design process to develop a solution, use the Ecosystems: Flow of Matter and Energy Rubric to assess their demonstration of learning. A printable version of the rubric is accessible in the Resources section on the **Summative Assessment** page. Use the rubric as a guide throughout the process of solving the problem.
8. Become familiar with the **Decision Matrix**. The decision matrix is a tool that allows students to rate the designs based on the criteria. If desired, you can print a copy of the decision matrix for each student to complete and glue in their Launch Log.

### Part 2. The Action Plan

1. Prepare a sample concept map on a piece of chart paper. Another option is to create the chart using the ShowMe Interactive Whiteboard app and project the chart for students to view.




2. Anticipate the ecosystems that students may select. Review the Ecosystems Presentations in the student course, as well as the **Research Resources**. Select books, websites, articles, and other material students can use to do research during the Explore portion of the design process.

### Possible Student Misconception

**Humans cannot do anything to change or fix ecosystems**. While we may not be able to reverse damage that has already occurred, we can help to prevent further impact on our ecosystems by reducing plastic and food waste, conserving energy and water, and investing in renewable energy.

## Procedure

**Time**: 180 Minutes

### Part 1. Local Impacts on Ecosystems

1. Review the Introduction Story: *Coyote Mystery* with students.
2. Direct students to access the problem in the student course and have them read the Introduction.
3. Have students prepare their PLTW Launch Logs for the problem.
4. Lead a discussion to review ecosystems.

- How does energy move through an ecosystem? What can disrupt this flow of energy? Direct students to access the flashcard example to review the vocabulary term *ecosystem*.
- Ecosystems are impacted by biotic and abiotic factors. What are examples of each of these? Direct students to access the flashcard examples to review the vocabulary terms *biotic factor* and *abiotic factor*.
- How can an ecosystem become unbalanced? Direct students to access the flashcard example to review the vocabulary term *unbalanced ecosystem*.

5. Have students select the type of ecosystem they want to research. Place students with similar interests in groups. Students should work together in groups of two to four.
   - Freshwater
   - Marine
   - Grassland
   - Forest
   - Desert
   - Tundra
6. Direct students to view their corresponding Ecosystem presentation to learn about the ecosystem they have selected.
7. Guide students to reflect on local ecosystems. Have them work with a partner to:
   - Identify local ecosystem(s)
   - Determine examples of these local ecosystem(s) becoming unbalanced
   - Brainstorm examples of plants, animals, and human actions that cause the ecosystem(s) to become unbalanced
   - Document their thinking in their Launch Logs

> **Notes**
> - As noted in the Preparation section, use the materials that you gathered to help students think about and discuss local ecosystems. Direct students to explore the materials and identify local ecosystems that have become unbalanced.
> - Have the representative from a local environmental agency (that you arranged earlier) speak to your students about ecosystems.

8. Guide students to share the examples they brainstormed. Record student responses on the Local Ecosystems chart.

> Examples of ecosystems, species, and human actions that affect them:
> - Wetlands polluted by humans
> - Grasslands damaged by grazing livestock
> - Expanding cities and/or suburbs reducing the habitats of plants and animals

9. Lead a discussion about the potential consequences of not protecting our local ecosystems. Direct students to access the flashcard example as you introduce the vocabulary term *consequence*.

## Part 2. The Action Plan

10. Guide students to choose an unbalanced ecosystem to design an action plan for.

> **Note**: The ecosystem should be specific, such as the Amazon Rainforest, rather than broad, like "a forest."

11. Direct students to access the flashcard example as you introduce the vocabulary term *design process*.
    - Ask students to share examples of how they have used a step-by-step process to complete a task. Examples include:
      - Getting ready for school
      - Brushing their teeth
      - Solving a math problem
      - Making a snack
    - Explain to the students that they are going to use the same steps that engineers use to design new items and improve existing items.
12. Present the Design Process video as an introduction to engineers and the design process.




Design Process video

13 Lead a discussion about what students learned from the Design Process video.

- Why might ecologists use the design process?
- How do you think the design process helps ecologists in their work?
- Why is it important to ask questions as you work through the design process? Why do you think that?
- In the video, we learned that it is important to understand the problem before looking for a solution. Have you ever identified a problem and then looked for a solution? Allow students to share their thoughts.

14 Explain to the students that they are going to use the design process to create an action plan to protect the plants and animals in a specific ecosystem. Students will prepare a digital product to share their action plan with their classmates. Direct students to access the flashcard example as you introduce the vocabulary term *action plan*.

15 Guide students to locate the page in their Launch Logs titled, "Solving the Problem." Students use this section to take notes as they work through the design process to write an action plan. Remind students to include details that provide evidence for their thinking.

16 The first step in the design process is **Ask**.

- Explain that to create an action plan, we must first understand the causes of the problem. Guide a discussion where students ask questions to gather information that will help them define and understand the problem.

- What does your ecosystem look like? What plants and animals make up this ecosystem?
- How is human activity causing this ecosystem to become unbalanced? (cause)
- What consequences does this unbalanced ecosystem have on the habitat and organisms? (problem)
- How could we protect the plants and animals in this unbalanced ecosystem? (solution)

- With support and guidance, the students define the problem, "How can we design an action plan to protect the plants and animals in an ecosystem?"
- Use the flashcard examples to introduce the vocabulary terms *criteria* and *constraint*.
- Introduce the criteria and constraints of the design.

| Criteria | Constraints |
|---|---|
| The action plan:<br>• Focuses on one unbalanced ecosystem.<br>• Explains the cause of the unbalance.<br>• Explains a consequence to a minimum of one organism.<br>• Explains how to protect the plants and animals in the ecosystem.<br>• Lists a minimum of two changes in human behavior to help keep the ecosystem in balance, such as preserving habitats and food webs.<br>• Must be presented in the form of a digital product. | • Time<br>• Digital product apps<br>• Available research |

- Guide the students in a discussion to consider the problem, criteria, and constraints.
- Guide students to record their responses in the Ask step of their Launch Logs.

- Have students complete the self-reflection at the end of the Ask section in their Launch Logs. Guide students to circle one statement in each row. Assess student understanding and record comments as needed.

> **Note**: At the end of each stage of the design process, students complete a self-reflection. This self-reflection is intended for students to provide honest feedback about their skills during each stage. They are not expected to be "advanced" in all areas all the time. Explain to students that this self-reflection is intended to help them grow as problem-solvers.

17 The second step in the design process is **Explore**.

- Show students your sample concept map, as well as the example in the student course.
- Guide students to conduct additional research on their ecosystem. See **Research Resources** for research options.
- Have students record their research findings in the Explore section of their Launch Logs. They should organize their research and represent their ecosystem's food web using a concept map. They also need to identify human impact on the food web and ecosystem.
- Encourage students to answer their questions from the Ask section, as well as:



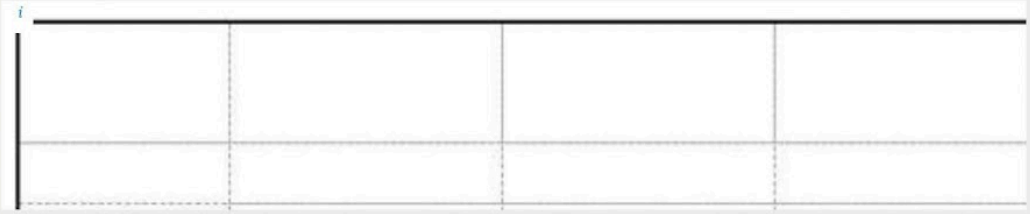
- How is human activity altering your ecosystem?
- Which producers, consumers, and decomposers are being affected? Use the flashcard examples to review the vocabulary terms *producer*, *consumer*, and *decomposer*.
- What is the evidence of the consequences? What data or observations show this?
- How have others tried to solve this or similar problems?

- Guide students to brainstorm several ideas that may solve the problem. Students may use the skills and knowledge they gained from the activities and project in this module, as well as information they gathered from their research.
- In the corresponding section of their Launch Logs, students record ideas for their solution.
- Guide students to share their initial ideas with their group. Encourage them to add any new ideas by writing or sketching in their Launch Logs.
- Have students complete the self-reflection at the end of the Explore section in their Launch Logs. Assess student understanding and record comments as needed.

18 The third step in the design process is **Model**.

- Introduce a decision matrix as a way to decide on the best action plan. Using the **Decision Matrix**, students rate each group member's action plan based on a 0–1 scale for each category. If the action plan does not meet the criterion in a category, it receives a 0 in that category. If the action plan does meet the criterion, it receives a 1. The action plan with the highest total score offers the best solution from the group.

> **Note**: Students may use the decision matrix in their Launch Logs or the copy you provide. If they use the one in their Launch Logs, they need to complete the column and row headers as shown.



- Guide students to use the chosen solution to create their action plan.
- Remind students to revisit the criteria so their action plan contains all elements.
- To facilitate creation of the action plans, circle around the room and assess student progress. Ask students to share their ideas and their thinking with you as they work.
- Have students complete the self-reflection at the end of the Model section in their Launch Logs. Assess student understanding and record comments as needed.

19 The fourth step in the design process is **Evaluate**.

- Guide students to reflect on the strengths and weaknesses of their action plan.



- How effective would the steps be in protecting the plants and animals in your ecosystem?
- Would there be any negative consequences to the steps?
- What else can you do or say to convince others to help?

- After students identify the strengths and weaknesses of their plan, have them revise it to make it better.
- Have students complete the self-reflection at the end of the Evaluate section in their Launch Logs. Assess student understanding and record comments as needed.

20 The fifth step in the design process is **Explain**.

- Guide students to create a digital product, such as a podcast or video blog, to share their action plan with the class and encourage others to take action.
- The digital product should include:
  - The ecosystem
  - The cause of the unbalance
  - A consequence to a minimum of one organism
  - A minimum of two changes in human behavior to help keep the ecosystem in balance by preserving habitats and food webs
  - Evidence for why this plan will work
- Allow time for students to share their digital products.
- After all presentations, lead a discussion about the different action plans.



- What key takeaway do you have after viewing all the presentations?
- If you could improve anything about your action plan, what would you improve? Why would you improve that aspect?
- If you could write another action plan, what problem would you research? Why would you research that?
- How can you apply what you have learned to your life?

- Guide students to complete the Explain section of their Launch Logs. Have students provide suggestions for improvement to their action plan and support those with evidence.
- Have students complete the self-reflection at the end of the Explain section in their Launch Logs. Then assess student understanding and record comments as needed.

21 Guide students to answer the Conclusion Questions. Lead a discussion for students to share their thoughts.

22 Direct students to complete the Ecosystems: Flow of Matter and Energy Check for Understanding. Access a printable version of this assessment in the Resources section of the **Summative Assessment** page.

## Conclusion Questions Answer Key

1 Do you think your local ecosystem is in balance? Consider the food web of producers and consumers that may have been here before buildings in your area were constructed. Provide evidence to explain your answer.

Student responses will vary. They should demonstrate an understanding of food webs and what makes one balanced or unbalanced. Additionally, students should demonstrate knowledge of what types of organisms are producers and consumers.

2 How can you take what you have learned about balanced ecosystems and share it with others outside the classroom? Why is this important?

Student responses should demonstrate an understanding of the importance of ecological awareness in their community and the effects of unbalanced ecosystems, as well as their own ability.

Introduction to the Module

# Infection: Detection

Teacher Resources



**Distance Learning Support**

For information about PLTW's distance learning support and online learning guides, jump to Distance Learning Support in **PLTW Launch Module-specific PD Resources**.

For distance learning support for facilitating this module, jump to **Distance Learning Support: Infection: Detection Teacher Guide**.

## PREFACE

**Time:** 10 instructional hours

In this module students are presented with a problem where a large number of students at a school are sick. Students learn about transmission of disease through a simulation and compare communicable and non-communicable diseases. Students design, run, and analyze data from an experiment related to preventing the spread of germs. Student groups present ways to prevent the spread of infection using evidence from their experiments. Students investigate how the body protects us from these germs to keep us healthy. Bacteria and viruses are introduced as agents of disease, and students use information learned and patient symptoms to identify the disease agent causing a simulated disease outbreak. Using epidemiology practices, students deduce a likely source of an infection that is spreading through a fictional school.

## TRANSFER

T

*Students will be able to independently use their learning to ...*

1. Identify behaviors to maintain health and prevent the spread of infection.
2. Apply a step by step process to design and perform investigations to find answers to questions.
3. Utilize critical thinking skills to solve a problem.

## UNDERSTANDINGS

U

*Students will understand that ...*

1. Scientists ask and identify questions to gain knowledge or solve problems.
2. Scientists develop and use models to represent amounts, relationships, relative scales, and/or patterns in the natural and designed world(s).
3. Scientists plan and conduct investigations collaboratively to produce data that serves as evidence used to answer questions.
4. Scientists make predictions based on prior experiences.
5. Scientists make observations and/or collect data to construct evidence-based conclusions for natural phenomena.
6. Scientists keep and organize all of their work in a scientific notebook.
7. Scientists work collaboratively and communicate their findings with others.
8. The design process is a step by step method used to guide people in developing solutions to problems.
9. Infectious agents, such as bacteria and viruses, can cause illness and can spread from person to person.
10. The body protects and defends itself from infection.
11. Understanding how infectious disease spreads in a population helps medical professionals with prevention efforts.

## KNOWLEDGE

K

*It is expected that students will ...*

- Recognize that germs can make a person sick.
- Recognize that bacteria and viruses are germs.
- Describe the various ways germs can be passed from person to person.
- Recognize that bacteria and viruses are microscopic in size and that they cannot be seen with the naked eye.
- Identify the ways that the body protects and defends itself against infection.
- Identify behaviors that promote good health.

## SKILLS

S

*It is expected that students will ...*

- Use scientific tools to examine cells or organisms that are microscopic.
- Perform an investigation in order to draw conclusions.
- Maintain a notebook to document work.
- Share findings and conclusions with others.
- Organize and analyze medical data to determine a likely source of an infection.
- Demonstrate the spread of infection using a graphical organizer and justify connections between infected individuals.
- Follow a step by step method to solve a problem.

## ESSENTIAL QUESTIONS

EQ

1. How can germs be spread from person to person?
2. How does the body defend itself from infectious disease?
3. How can medical professionals use patient symptoms to diagnose illness?
4. How can scientists determine how a germ spreads through a group of people?

## RESOURCES

- Curriculum Framework
- Connections to Standards
- Fifth Grade Connections to Standards
- Family Letter
- Additional Instructional Resources
- Fifth Grade Curriculum Revisions
- Device Specifications
- Application List

# Preparation

**Note:** In preparation for teaching this module, it is strongly recommended that the teacher read the Infection: Detection Teacher Resources, including the Understandings, Knowledge, and Skills addressed in the module. Detailed instructions are provided in the Teacher Resources for each activity, project, or problem.

## Curriculum Framework and Connections to Standards

Before you facilitate this module, review the Curriculum Framework and Connections to Standards documents.

Standards are the foundation for what is taught in a classroom. They outline what students are expected to learn and be able to do as a result of participating in learning experiences. When planning the implementation of any curriculum, it is essential to identify which standards the curriculum addresses and any standards it does not. This offers greater insight into what the curriculum provides your students and any standards that you may need to address beyond the content provided.

For each PLTW Launch module, teachers are provided a curriculum framework document, which offers a three-stage approach to curriculum planning, assessment, and instruction. The framework document offers a big picture view of the module including the desired results of student learning, assessment opportunities that call for evidence of student learning, and an overview of the scaffolded approach to student learning.

Within the desired results of student learning in the curriculum framework, information is included about module connections to the following standards, when applicable:

- Next Generation Science Standards (NGSS)
- Common Core State Standards (CCSS) in English/Language Arts (ELA) and Mathematics
- Computer Science Teachers Association K–12 Computer Science Standards (CSTA)
- International Society for Technology in Education (ISTE)
- National Association for the Education of Young Children (NAEYC) Early Learning Program Standards
- Head Start Early Learning Outcomes Framework

We understand that your state might not align to these bodies of standards. That is why PLTW Launch is designed for flexible implementation. If your state does not address these standards, spend time comparing your state standards to those identified for the module. Remember that PLTW Launch modules can be implemented at any PreK–5 grade level based on your state standards. Also keep in mind that if you implement a module at a different grade level than indicated, you might need to make modifications to meet the needs of your students.

Exploring this framework resource before you examine the Teacher Guide gives you a high-level understanding of the stages to curriculum planning, assessment, and instruction. You can also determine how the module connects to the required standards for your state. After you have explored the curriculum framework document, you'll be ready to explore the step-by-step instructions in the Teacher Guide.

## Professional Development

### Resources

Before you facilitate the Infection: Detection module, review the professional development resources.

- Access the **Launchpad** to review:
  - Three Dimensional Learning
  - Claims and Evidence
  - The Teacher as Facilitator
  - PLTW Formative Assessment
  - Using PLTW Launch Logs
  - Uncovering and Addressing Misconceptions
  - The APB Instructional Approach
  - Setting the Stage for APB Learning
  - Thinking Like an Engineer
  - Developing Research Skills with Elementary Students
  - The Design Process Song: Version 1
  - The Design Process Song: Version 2
- Access the **Infection: Detection Module-specific PD Resources** to review:
  - Infection: Detection APB Overview
  - Building Your Understanding: Germs
  - Scientific Inquiry Process video
  - Accessing Additional PD Resources

### Transportable Skills

PLTW learning experiences offer opportunities for students to build transportable skills they can use in the classroom and beyond. Transportable skills include problem-solving, critical and creative thinking, collaboration, communication, and ethical reasoning and mindset. As a facilitator of learning, you play a vital role in fostering the development of these skills as students explore phenomena.

To build your understanding of how transportable skill development is embedded within PLTW Launch and discover literature connections that illustrate these skills, explore these resources in the **Launchpad**:

- Developing Transportable Skills
- Transportable Skills: Literature Connections

### Questioning Skills

As you facilitate APB learning, asking probing questions is essential. Within each activity, project, and problem throughout this Teacher Guide, you will notice sample prompts to ask your class. The prompts guide you to ask thought-provoking questions, as well as to identify conceptions and misconceptions.

As you work with your students, remember that you are not limited to the prompts provided. The best way to determine the types of questions to ask your students comes from observing and interacting with your students as they engage in the module. This provides formative assessment of students' conceptual development and allows you to uncover and address misconceptions.

Building your questioning skills increases your capacity to facilitate powerful student learning. For more information, review the following professional development resources in the **Launchpad**:

- The Art of Questioning
- Building Your Questioning Skills
- Question Bank

## Family and Community Relationships

Family and community relationships are encouraged throughout the module. A **Family Letter** is provided to introduce Project Lead The Way to families, and encourage families to support students' learning of concepts at home. PLTW recommends that you send this letter to families before you begin a module, to let them know what their students will be learning in school.

FAMILY CONNECTION

In the problem, a Family Connection section is identified by this house icon. This section provides activities families can do to support what students are learning. Families can use the log-in information provided in the Family Letter to access the course activities.

## Developing Vocabulary

Vocabulary learning has been found most effective when active engagement with a term goes beyond just knowing the definition. Rather than presented in isolated lessons, vocabulary is introduced within the context of the activities, project, and problem. Viewing the course on a digital device, students have as-needed access to a glossary and interactive flashcards. Each card has an audio component, so students can independently review these words throughout the module.




0:00 / 0:05

## Icon Legend

Throughout the Teacher Guide, the following icons have special meanings.



### Digital Device

The Digital Device icon indicates times when you or your students will use a device for a learning experience.



### Camera

The Camera icon indicates when you or your students will use a camera for a learning experience. There are many camera options. When possible, the best option is for the students to use the camera on their digital device. However, you might need to assign a class photographer to use a digital camera, or you may be the photographer with the camera on your smartphone.

## Additional Instructional Resources

Project Lead The Way understands the importance of introducing literature, music, and rhyme to students in the early years. As such, we created **a list of additional resources** specific to this module. These resources are not included in the equipment kit, and they are not covered in the 10 instructional hours of the module. Incorporating the resources is optional, but they offer ways to provide additional engagement with the concepts explored in this module.

## Curriculum Revisions

The Launch curriculum is continuously updated to provide content and instructional resources that are current and based on best practices. Significant revisions to the curriculum implemented since the prior release of Launch are documented in the **Fifth Grade Curriculum Revisions**.

Activity 1

# Germs, Germs, Everywhere

Teacher Resources

View Student Course

## EQUIPMENT

The list below is based on a class of 30 students.

| Included in Equipment Kit | Not Included in Equipment Kit | Device Applications |
|---|---|---|
| • Simulated germ powder<br>• Ultraviolet, UV, flashlight (1 per group) | • Launch Logs (1 per student)<br>• Digital devices<br>• Colored pencils or markers | • Inkling<br>• Popplet Lite (iPad® only, Optional)<br>• ShowMe Interactive Whiteboard (Optional) |

## RESOURCES

- Launch Log Grades 3-5
- Introduction to Infection: Detection
- GlitterBug® Powder Safety Data Sheet

## KNOWLEDGE AND SKILLS

KS

By the end of this activity, students will be able to ...

- Recognize that germs can make a person sick and that bacteria and viruses are germs.
- Describe the various ways germs can be passed from person to person.
- Identify behaviors that promote good health.
- Maintain a notebook to document work.
- Share findings and conclusions with others.
- Organize and analyze medical data to determine a likely source of an infection.
- Demonstrate the spread of infection using a graphical organizer and justify connections between infected individuals.

## ESSENTIAL QUESTIONS

EQ

1. How can germs be spread from person to person?
2. How does the body defend itself from infectious disease?
3. How can medical professionals use patient symptoms to diagnose illness?
4. How can scientists determine how a germ spreads through a group of people?

## Preparation

- Determine ways you can support the development of transportable skills in this module. Examples include calling out ways students demonstrate the skills, asking questions that allow students to reflect on their development of the skills, and integrating books listed in the Transportable Skills: Literature Connections resource.
- Review the **Additional Instructional Resources**. This list includes books that offer diverse perspectives that can expand student understanding. Using these resources provides a sense of inclusion and belonging, and helps students make connections if the content is new to them.
- Think of ways to establish community relationships throughout the module. To encourage career connections in the classroom, invite local community members to work alongside your students or speak to students about their careers.

## Activity 1: Germs, Germs Everywhere

**80 minutes**

- This activity may be taught over a series of class periods as determined by the teacher and is estimated to take 80 minutes to complete.
- The teacher introduces students to the device login process. For the remainder of the module, the students will access the assignments through the device and record their work in their individual Launch Logs.
- Prior to starting this activity, the teacher introduces students to the Launch Log as a place to document their work throughout the module. Students take notes as they research, create sketches, and answer conclusion questions in this notebook.
- Prior to working through Activity 1, the teacher guides students as they play a modified version of the game Seven Up. The teacher does not tell students why they will be playing this game, as it is part of the fun.
  - The teacher chooses seven random players to be up first. These seven students will stand in the front of the class, and the rest of the students will remain in their seats.
  - The teacher will say "heads down arms up" and everyone seated should put their heads down on their desk or table and put their right hand up in the air (as though they are raising their hand). These students need to keep their head on their desk or table, and they may not look at what is happening in the class.
  - The seven people who are standing should go around the room, and each should quietly give one person of their choosing a handshake. As they are doing this, the teacher should discreetly pick one player and lightly dust a small amount of the simulated germ powder over the entire surface of his or her hand. They should be told that they will be passing on a simulated germ to their classmates, but they cannot tell anyone what they are doing and need to keep this a secret. The teacher needs to pick a student that they can trust to be discreet and keep the secret. If the other students who are standing see this occur, they also need to be told that they cannot disclose the secret. In case any student notices that they have the powder on their hands, make sure that they are told to be discrete so that they don't ruin the mystery for the other students.

    **Notes:**

    - The simulated germ powder is not a known skin irritant. In the rare event irritation occurs, simply wash hands thoroughly with soap and water. Please refer to the **Safety Data Sheet** for more information.
    - If you have concerns about a student with sensitive skin or allergies, have that student be the caller who tells others when to stand and put down their heads.

  - The teacher reminds the seven standing students to remember who they gave a handshake to, as they will record this information later in their Launch Logs.
  - Any student who received a handshake has to put their hand down. When each of the original seven students has given someone a handshake, they should stand in the front again and the teacher will say "heads up seven up."
  - Everyone who received a handshake stands up.
  - Each "tagged" student has to guess who tagged them out of the original seven students. If they get it right, they become one of the seven people to stand at the front of the room, switching spots with the person who tagged them. If they get it wrong, they stay seated and the person who tagged them stays standing.
  - Students will continue to play for a total of five rounds. The teacher reminds each of the seven players who are standing during each round to remember who they have given a handshake to.
- Once the game is over, the teacher directs all students to record anyone they gave a handshake to during the game.
- The teacher assists students in accessing the Infection: Detection module in the curriculum course.
- As part of the activity, the teacher reads the Infection: Detection Introduction, which is a fictional story that introduces the problem. The Introduction may be accessed in the curriculum course or printed for students.
- After reading the fictional story, the teacher leads the students in a discussion about the problem presented.
- The teacher introduces Activity 1: Germs, Germs Everywhere. In this activity students will track and analyze the spread of germs through the modified version of the Seven Up game.

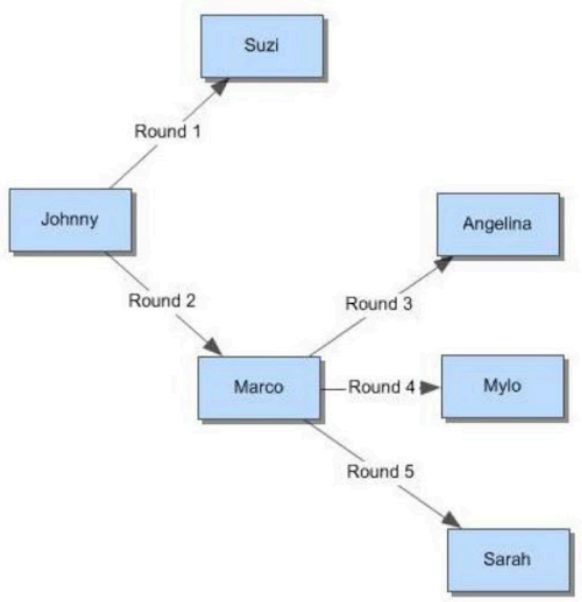
  **Note:** At the end of this activity, it is important to communicate to all students that this was a simulation of the transfer of germs. Assure students that the simulated germ powder contains no real germs.

- The teacher directs students to read the procedures for this activity

- The teacher directs students to read the procedures for this activity.
- Students work through the activity. Once students get to Step 6 in the procedure, they are asked to follow along as the teacher guides a class discussion to determine the chain of infection. The teacher asks students to raise their hand if they have Glow Germs on their hands. The teacher writes down the students' names on the board in a vertical list. The teacher should then write down all of the students each affected person gave a handshake to, as shown in the example below.

| Students with Glow Germs: | Students they shook hands with: |
|---|---|
| Johnny | Suzi<br>Marco |
| Suzi | |
| Marco | Angelina<br>Mylo<br>Sarah |
| Angelina | |
| Mylo | |
| Sarah | |

- The teacher guides students to use this information to determine the chain of infection. Students will record the chain of infection in their Launch Logs and explain how the germs were spread, as shown in the example below. Alternatively, students may use Popplet Lite or ShowMe Interactive Whiteboard to showcase the chain of infection.
  Example scenario:
  - Round 1: Johnny had Glow Germs on his hand. Johnny transmitted the germs to Suzi when he gave shook her hand. Suzi did not guess Johnny, so Johnny got to be up in front again.
  - Round 2: Johnny transmitted the germs to Marco when he shook his hand. Marco guessed Johnny, so he replaced Johnny up in front.
  - Round 3: Marco transmitted the germs to Angelina when he shook her hand. Angelina did not guess Marco, so Marco got to be up in front again.
  - Round 4: Marco transmitted the germs to Mylo when he shook his hand. Mylo did not guess Marco, so Marco got to be up in front again.
  - Round 5: Marco transmitted the germs to Sarah when he shook her hand.
    Example chain of infection:




- The teacher presents the Modes of Transmission presentation and students take notes in their Launch Log.
  **Remember** to assure all students that the activity involved a simulated germ powder and no actual germs.
- When students explore careers, they can see connections between what they are learning and real-world applications. Guide students to read about Beth Tedasse to learn about a career in contact tracing.
- The Conclusion Questions may be answered individually in the Launch Log or may be discussed in large or small groups.

## Conclusion Questions Answer Key

1 How can the spread of a communicable disease be reduced?

Student responses should demonstrate an understanding of communicable diseases. Example response:
*To reduce the spread of communicable disease, I can wash my hands often, sneeze and cough in my sleeve, and wear a mask.*

2 In the Introduction Story, Mylo wants to figure out how the mystery illness started at school and passed from person to person. In the problem, this is what you will be asked to do! Think about how you can apply the process you used in this activity to identify the chain of infection in a bigger outbreak at a school. What information do you think you need?

Student responses should demonstrate an understanding of communicable diseases. Example response:
*If there was a large outbreak at school, I would need to know who is sick and who they have been in contact with.*

Activity 2

# Preventing the Spread

Teacher Resources

View Student Course

## EQUIPMENT

The list below is based on a class of 30 students.

| Included in Equipment Kit | Not Included in Equipment Kit | Device Application |
|---|---|---|
| • Simulated germ lotion<br>• Ultraviolet, UV, flashlight (1 per group)<br>• Disposable transfer pipettes<br>• Various soaps:<br>  ◦ Bar soap<br>  ◦ Liquid hand soap<br>  ◦ Foaming antibacterial soap | • Launch Logs<br>• Digital devices<br>• Colored pencils or markers<br>• Rulers<br>• Scientific Inquiry Process resource sheets<br>• Experiments Resource Sheets<br>• Experiment Data Sheets (Optional) | • Inkling |

## RESOURCES

Example Experiments Resource Sheet

Scientific Inquiry Process

Experiment Data Sheet

## KNOWLEDGE AND SKILLS

KS

By the end of this activity, students will be able to ...

- Identify behaviors that promote good health.
- Perform an investigation in order to draw conclusions.
- Maintain a notebook to document work.
- Share findings and conclusions with others.

## ESSENTIAL QUESTIONS

EQ

1. How can germs be spread from person to person?
2. How does the body defend itself from infectious disease?
3. How can medical professionals use patient symptoms to diagnose illness?
4. How can scientists determine how a germ spreads through a group of people?

## Preparation

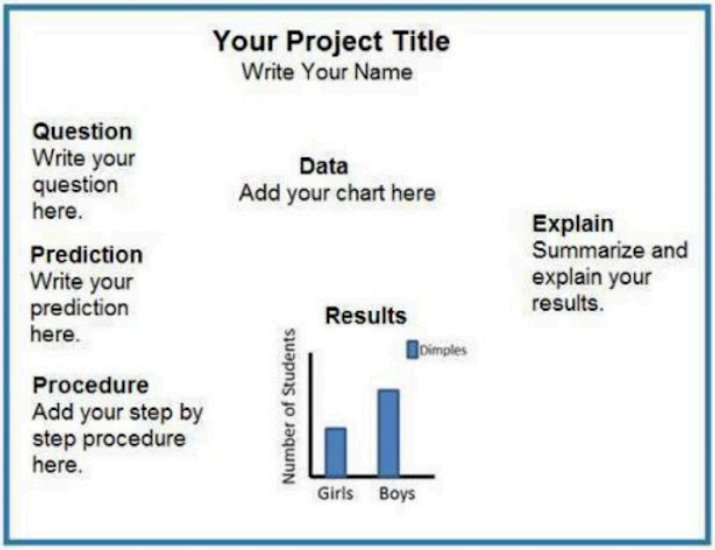
Review the **Additional Instructional Resources**. This list includes books that offer diverse perspectives that can expand student understanding. Using these resources provides a sense of inclusion and belonging, and helps students make connections if the content is new to them.

## Activity 2: Preventing the Spread

**160 minutes**

- This activity may be taught over a series of class periods as determined by the teacher and is estimated to take 160 minutes to complete.
- The teacher introduces Activity 2: Preventing the Spread and directs students to access the activity using the device.
- Prior to running this activity with students, the teacher prints the **Example Experiments Resource Sheet** for each student.
- In this activity students will work with a partner to design and perform an experiment to test the effectiveness of different hand washing methods. They will follow the scientific inquiry process to collect and analyze data and to draw conclusions.
- Students read the procedure for Activity 2.
- The teacher tells the students that they are going to perform an experiment to test the effectiveness of different soaps and hand washing methods. Students will be responsible for designing their own experiments and then actually performing their experiment to gather data and draw conclusions.
  - Before they begin this process on their own, the teacher will guide them through two example experiments.
  - Half of the class will perform Experiment 1, and the other half will perform Experiment 2.
  - Students will analyze the two alternatives to determine best practice with experimental design.
  - The teacher walks them through the scientific inquiry process with the example experiments and uses the experience to introduce experimental design and methods such as using a control group.
- The teacher distributes an Example Experiments Resource Sheet to each student. Students will use this resource sheet to help guide them through all of the steps of the inquiry process as they complete the example experiments. They should record any information in their Launch Logs, as indicated in the resource sheet.
  - The first step of designing an experiment is to figure out what question you are trying to answer and ***ask*** that question. Remember that because you want to perform an experiment to answer your question, your question needs to be something you can actually test.
    - The question we want to answer is: Does washing your hands with bar soap work to clean your hands of germs? Students should record this question in their Launch Logs.
  - The next step of the inquiry process is to ***predict*** the answer to the question.
    - Ask the students to come up with a prediction for the experiment. Do they think that washing their hands with bar soap will work to clean their hands of germs?
    - Ask the students how they can find out whether their predictions are correct or not. What materials will they need? What do they need to do?
  - The next step of the inquiry process is to ***investigate*** the answer to their question.
    - The teacher demonstrates how to use the simulated germ lotion.
      - Dispense a penny-sized drop of GlitterBug® Potion on the palm of your hands.
      - Rub hands together thoroughly and sufficiently cover all surfaces (both front and back) with the lotion.
      - Turn off the lights.
      - Examine hands for fluorescence with the UV flashlight. This fluorescence simulates the presence of germs, which were called Glow Germs in the previous activity. Please note that the lotion does not indicate the presence of real germs.
      - Wash your hands with soap and water.
      - Reexamine hands for fluorescence with the UV flash light to see how well you washed off the simulated germs. Hands are very clean when there is no remaining fluorescence. Bright spots show hard to clean cracks and crevices where germs like to hide.
    - The teacher tells students that in order to investigate, they need to follow a *procedure*, or step by step instructions, for exactly how to perform the experiment. For this example experiment, a procedure will be provided to them.
    - The teacher assigns half of the class the *Experiment 1* procedure and the other half of the class the *Experiment 2* procedure. Because Experiment 2 will take longer than Experiment 1 to complete, those students who worked through Experiment 1 should take any extra time to read through Experiment 2 and highlight any differences between the two experiments.
  - The teacher directs students to work in groups to perform their assigned procedures and to record their ***observations*** of their findings.
    - Students should draw the corresponding data table for their assigned example procedure in their Launch Logs.
    - Students perform their assigned example procedures and record all observations in their data tables in their Launch Logs.
    - The teacher helps students with the calculations for finding the average rating for experiment 2.
  - The teacher directs students to explain their findings for their assigned experiments in their Launch Logs.
    - Explain what you learned from your investigation. Use data from your investigation as evidence.
    - Explain whether your data supports your prediction.
- The teacher directs student groups who completed experiment 1 to pair up with students who completed experiment 2. Students will compare the two experiments to determine any differences and discuss which experiment has a better design and why. They should record their reasoning in their Launch Logs.
- The teacher guides a discussion about what was done in both experiments and discusses the differences between the two experiments, and why experiment 2 was a better designed experiment than experiment 1.
  - Experiment 2 has the students compare the results of washing their hands with plain water to washing their hands with soap.
    - This is very important to do in an experiment, as you always need a standard for comparison to make sure your results were in fact due to whatever is being tested. For this experiment, in order to make sure that the cleaning off of the germs was due to the bar soap, it was necessary to wash the hands with plain water without soap, to see what effect that had, and then compare this to washing the hands with the soap. The part of an

experiment that is used for comparison is called the *control group*.
  - Experiment 2 has the experimenter repeat all steps again so that there are two trials for both the control and experimental group.
    - This is very important to do in an experiment so that the experimenter knows the results were not a fluke. If an experimenter only runs one trial for an experiment, there is no way for them to know if their results were a fluke and if they'd receive the same or similar results if they were to perform the experiment again.
  - Experiment 2 includes both a picture of the results as well as a rating scale to quantify the results.
    - It is important to quantify results of an experiment in order to present unbiased information to others.
  - The teacher should also note that Experiment 2's procedure was written to keep everything consistent.
    - The entire procedure was repeated exactly how it was performed the first time, but instead of washing with plain water, the hands were washed with the bar soap.
- The teacher tells students that after a researcher performs an experiment, there are a variety of next steps, as the inquiry process does not end at the end of an experiment. Possible next steps are:
  - Apply what was learned from the experiment to real-world problems.
  - Redesign the procedure and carry out the experiment again if there were any flaws in the experimental design.
  - Develop new questions based on the findings for this experiment.
  - Move on to a new or related research topic.
- The teacher tells students that they will now use the scientific inquiry process to design and perform an experiment to test the effectiveness of a hand washing method for a particular soap. They will need to ask a question they are interested in pursuing, make predictions, write a procedure, carry out their procedure, record observations of their results, and explain their findings. They should use example experiment 2 as a model for a well-designed experiment. If students are struggling with experimental design, the teacher can have students complete the design portion together as a class.
- Sample questions students might choose to investigate include:
  - Does washing your hands for different amounts of time affect how well liquid hand soap removes germs?
  - Does washing your hands with bar soap clean your hands better than washing your hands without soap?
  - Which soap is the most effective at washing your hands – liquid hand soap, antibacterial liquid hand soap, or bar soap?
- It is at the discretion of the teacher to allow students to pursue questions related to the prevention of the spread of germs that do not involve hand washing. For example, a student may want to investigate whether using a fist bump versus a hand shake is a way to prevent the spread of germs.
- Note that there is an optional **Experiment Data Sheet** available for students to record their experimental design and experimental results if the teacher chooses not to have students record all of this information in their Launch Logs.
- If desired, students could create a mini poster presentation of their work. An example poster format is shown below.




- The teacher directs students to share their work with their classmates.
- The teacher should consider having a doctor or nurse visit the class and talk about all of the ways we can keep our bodies healthy.
- The Conclusion Questions may be answered individually in the Launch Log or may be discussed in large or small groups.

## Conclusion Questions Answer Key

1 Think about Example Experiments 1 and 2. Which one had a better design? Explain your reasoning.

Student responses should demonstrate an understanding of the scientific inquiry process. Example response:
*Example Experiment 2 had a better design. It was better because:*

- *It had a control group.*
- *We rated the amount of visible lotion.*
- *We repeated the steps to determine the average rating of the results.*

2 List two changes you would make to improve your investigation. Why do you think these changes would improve your investigation?

Student responses will vary.

3 Based on your findings, suggest two new questions that you now have for future investigations.

Student responses will vary.

Activity 3

# Infection Fighters

Teacher Resources

View Student Course

## EQUIPMENT

The list below is based on a class of 30 students.

| Not Included in Equipment Kit | Device Applications |
|---|---|
| • *Battle with the Bugs: An Imaginative Journey Through the Immune System* ebook, by Heather Manley (optional)<br>• Launch Logs<br>• Digital devices<br>• Body's Defenses Against Infection presentation<br>• Body outline (1 print per group)<br>• Colored pencils or markers | • Inkling<br>• Kindle Cloud Reader (optional) |

## RESOURCE

Body Outline

## KNOWLEDGE AND SKILLS

KS

By the end of this activity, students will be able to ...

- Identify the ways that the body protects and defends itself against infection.
- Maintain a notebook to document work.
- Share findings and conclusions with others.

## ESSENTIAL QUESTIONS

EQ

1. How can germs be spread from person to person?
2. How does the body defend itself from infectious disease?
3. How can medical professionals use patient symptoms to diagnose illness?
4. How can scientists determine how a germ spreads through a group of people?

## Preparation

Review the **Additional Instructional Resources**. This list includes books that offer diverse perspectives that can expand student understanding. Using these resources provides a sense of inclusion and belonging, and helps students make connections if the content is new to them.

## Activity 3: Infection Fighters

**80 minutes**

- The teacher prints a **Body Outline** for each group of students.
- This activity may be taught over a series of class periods as determined by the teacher and is estimated to take 80 minutes to complete.
- The teacher introduces Activity 3: Infection Fighters and directs students to access the activity using the device.
- In this activity students will explore the body's defenses and diagram how the body fights invasion from germs. Students will explore nonspecific defenses, defenses that are not targeted against a specific invader, such as the skin, cilia, and mucus in the nose and respiratory tract. These nonspecific defenses simply act as a barrier to keep foreign bodies from entering our system. Students will also begin to look at specific defenses, particularly the white blood cells, which target specific germs that enter the body. However, they will not go into detail about how certain white blood cells produce antibodies, proteins that target a specific invader.
- The teacher distributes a body outline (top and bottom) to each group of two students.
- Students will work through the **Body's Defenses Against Infection** presentation. If desired or if you have students with limited reading ability, consider delivering this presentation to the entire class or a small group.
  - Students use what they learned in the presentation to diagram all of the ways the body protects you from invasion by germs.
    1. Students will draw at least 6 substances, structures, or cells on the body outline that work to protect against germ invaders. The teacher may want to display an image of the human body that shows the placement of key organs.
    2. Students will label each of these defense mechanisms and include a text box that describes how the organ or structure works to keep the body safe.

> **Optional:** The teacher may choose to have students read the eBook *Battle with the Bugs: An Imaginative Journey Through the Immune System* for additional information on the immune system. This book looks a bit deeper into some of the specific body cells that function to target specific invaders.

- The Conclusion Questions may be answered individually in the Launch Log or may be discussed in large or small groups.

## Conclusion Questions Answer Key

1 Why do you think a person's lymph nodes may be swollen when they are fighting an infection?

Student responses should demonstrate an understanding of the immune system. Example response:
*As the lymph nodes try to fight off an infection, they swell. The lymph nodes filter bodily fluids, and trap and destroy any invading germs before they can enter the blood.*

2 Think of a time when you had a fever. Why might having a fever be considered a good thing?

Student responses should demonstrate an understanding of the immune system. Example response:
*A fever is a good thing because it makes the body a less favorable environment for germs to live.*

Project

# Mystery at School

Teacher Resources

View Student Course

## EQUIPMENT

The list below is based on a class of 30 students.

| Not Included in Equipment Kit | Device Application |
|---|---|
| • Launch Logs<br>• Digital devices<br>• Colored pencils or markers<br>• Disease cards (1 print per group)<br>• Microorganisms PDF<br>• Microorganisms Resource Sheet (1 print per student)<br>• Patient Information Resource Sheet (1 print per group) | • Inkling |

## RESOURCES

- Disease Cards
- Microorganisms Resource Sheet
- Microorganisms Fill-in Sheet
- Microorganisms Fill-in Sheet Answer Key
- Patient Information
- Patient Symptoms Chart

## KNOWLEDGE AND SKILLS

KS

By the end of this project, students will be able to ...

- Recognize that germs can make a person sick and that bacteria and viruses are germs.
- Recognize that bacteria and viruses are microscopic in size and that they cannot be seen with the naked eye.
- Use scientific tools to examine cells or organisms that are microscopic.
- Maintain a notebook to document work.
- Share findings and conclusions with others.
- Organize and analyze medical data to determine a likely source of an infection.

## LEARNING GOALS

LG

By the end of this project, students will be able to ...

- Recognize that germs can make a person sick and that bacteria and viruses are germs.
- Recognize that bacteria and viruses are microscopic in size and that they cannot be seen with the naked eye.
- Use scientific tools to examine cells or organisms that are microscopic.
- Maintain a notebook to document work.
- Share findings and conclusions with others.
- Organize and analyze medical data to determine a likely source of an infection.

ESSENTIAL QUESTIONS

EQ

1. How can germs be spread from person to person?
2. How does the body defend itself from infectious disease?
3. How can medical professionals use patient symptoms to diagnose illness?
4. How can scientists determine how a germ spreads through a group of people?

## Preparation

Review the **Additional Instructional Resources**. This list includes books that offer diverse perspectives that can expand student understanding. Using these resources provides a sense of inclusion and belonging, and helps students make connections if the content is new to them.

## Project: Mystery at School

**160 minutes**

- This project may be taught over a series of class periods as determined by the teacher and is estimated to take 160 minutes to complete.
- The teacher prints and cuts out a set of **Disease Cards** for each pair of students. Make sure to staple the top and bottom together so that only the disease name is showing on the top. Students will need access to these cards for the remainder of the project.
- The teacher prints out the **Microorganisms Resource Sheet**.
- In this project students investigate germs in depth and explore the two types of germs that are responsible for a majority of the communicable illnesses that infect humans, bacteria, and viruses. They will explore different diseases and apply their knowledge to identify the mystery illness spreading around Mylo, Suzi, and Angelina's school.
- The teacher introduces Project: Mystery at School and directs students to access the project using the devices.
- Students read the procedure on the device.
- The teacher either reads the Infection: Detection Introduction story or reminds students of the story that sets the stage for this project and the problem.
- Before beginning the activity, the teacher should hold a discussion about what it means to be sick versus well. In what ways does our body tell us that we are sick? Do different illnesses cause our body to react in different ways?
- The teacher guides them through the activity. Note that students should complete their first attempt at grouping the disease cards into communicable and non-communicable without reading the information inside of the card. It is OK if students are not familiar with all of the illnesses. Ask them to make their best guesses given the name of the illness. They will have a chance to regroup the cards once they have more information.
- After students have completed their first attempt at grouping their cards into communicable and non-communicable, they are asked to read the information inside of each card. The teacher should have students read through the information on each Disease Card together as a class to ensure students understand the information presented. The teacher will clarify any misconceptions or misunderstandings.
- The teacher may want to hold a class discussion about the differences between some of the diseases presented, as some are serious and some are relatively easy to treat and very common.
- Students should identify the following diseases as communicable:
    - Common cold
    - Strep throat
    - Measles
    - Flu (influenza)
    - Chickenpox
    - Whooping cough (pertussis)
    - Pink eye (conjunctivitis)
    - Ebola
    - Tuberculosis
- The teacher should note that the goal of looking at all of the communicable diseases presented is to identify that bacteria or viruses are the cause of all of these illnesses.
- For Part 2: Step 2, the teacher distributes a Microorganisms Resource Sheet to each student. Students will read informational text about bacteria and viruses on this resource sheet. For each section, students should underline or highlight any important information and write any main ideas in the column on the right. After they read through each section, they should answer the questions below. The teacher should model reading strategies for students to help them understand the information presented. Below are the answers to the questions presented in the resource sheet.
    - **Bacteria:**

1. What are bacteria?

*Tiny, one-celled organisms that get their nutrients from their environment in order to live.*

2. Where do bacteria live?

*Everywhere, including soil, water, and bodies of every person and animal.*

3. What do bacteria do in soil?

*Break down, or decompose, dead plants and animals.*

4. What do helpful bacteria do in our intestines?

*Break down food and give us the nutrients they contain.*

5. What do pathogenic bacteria cause?

*Illness*

**Viruses:**

1. What are viruses?

*Tiny, nonliving invaders.*

2. Why do viruses need to be inside living cells?

*To grow and reproduce.*

3. Viruses can last for short periods of time outside a host on what?

*Surfaces such as doorknobs or countertops.*

4. When viruses get inside a host, what do they do?

*They invade the host's cells and use it to make more copies of themselves.*

- The teacher displays a picture of *A. equuli* bacteria using the Microorganisms PDF. Students sketch a picture of the bacteria in their Launch Log. The teacher should note that the magnification shown is 1,000x. This this means that the bacteria is magnified 1,000 times more than what you can see with your naked eye.
- The teacher may choose to have students complete a **Microorganisms Fill-in Sheet** as a formative assessment for the readings on bacteria and viruses. Answers are provided in the **Microorganisms Fill-in Sheet Answer Key**.
- Students examine a picture of the influenza virus in the curriculum course. Students sketch a picture of the virus in their Launch Log. The teacher should note that the magnification shown is 450,000x. This means that the virus is magnified 450,000 times what you can see with your naked eye.
- Answers for the math questions from Part 2 of the procedure are shown below.
  - How much greater is the magnification of the influenza virus than the *A. equuli* bacteria?

    *Influenza virus = 450,000 x A. equuli bacteria = 1,000x*

    *The influenza virus is 450x more magnified than the A. equuli bacteria.*

  - If you had another bacterial cell that was magnified by only 100x, how much greater is the magnification of the *A. equuli* bacteria sample than this new sample?

    *Bacterial cell = 100 x A. equuli bacteria = 1,000x*

    *The A. equuli bacteria is 10x more magnified than the new bacterial cell.*

  - How much greater is the magnification of the 450,000x virus than the 100x bacteria?

    *Influenza virus = 450,000x Bacterial cell = 100x*

    *The influenza virus is 4,500x more magnified than the 100x bacterial cell.*

- Optional: For Part 3: Mystery Infection, the teacher prints and distributes a **Patient Information** resource sheet to each student. Students circle symptoms of each patient and underline or highlight connections between individuals.

- Students will then construct a table of student symptoms in their Launch Log. An example table is provided in the **Patient Symptoms Chart**. Note that student work may vary.
- Students will analyze symptoms shown in their table, summarize patterns in a paragraph in the Launch Log, and note that most patients complain of a sore throat, cough, and fever. They will use the Disease Cards to deduce that the most likely illness they are dealing with is strep throat.

> **Note:** Lily has gastrointestinal symptoms unlike any other student. The teacher helps students see that this case is unrelated.

- In the problem, students will have to trace the chain of infection through the school.
- The Conclusion Questions may be answered individually in the Launch Log or may be discussed in large or small groups.

## Conclusion Questions Answer Key

1 You overhear a friend stating that all bacteria are bad. Explain why this is not a true statement.

Student responses should demonstrate an understanding of bacteria. Example response:
*Not all bacteria are bad. Bacteria in soil help break down dead plants and animals. Bacteria in our intestines help us break down food.*

2 Scientists use different microscopes for different purposes. Compound light microscopes can magnify objects or organisms to 1000x their size. Scientists use these to view bacteria. Electron microscopes can magnify objects or organisms up to 10,000,000x their size. Scientists use these to view viruses. Why do you think scientists need to use an electron microscope to view viruses but not bacteria?

Student responses should demonstrate an understanding of viruses and bacteria. Example response:
*Viruses are much smaller than bacteria. That means scientists need a microscope with stronger magnification to see them. Since an electron microscope magnifies organisms up to 10,000,000x their size, scientists would use this microscope to view viruses but not bacteria.*

Problem

# Disease Detectives

Teacher Resources

View Student Course

## EQUIPMENT

The list below is based on a class of 30 students.

| Not Included in Equipment Kit | Device Applications |
|---|---|
| • Launch Logs<br>• Digital devices<br>• Colored pencils or markers<br>• Disease cards (from previous project)<br>• Patient Information Resource Sheet (from previous project)<br>• Evidence Documents Resource Sheet (1 print per group) | • Inkling<br>• Popplet Lite (Optional)<br>• ShowMe Interactive Whiteboard (Optional) |

## RESOURCES

- Tracing the Chain of Infection
- Evidence Documents
- Summative Assessment

## KNOWLEDGE AND SKILLS

KS

By the end of this problem, students will be able to ...

- Recognize that germs can make a person sick and that bacteria and viruses are germs.
- Describe the various ways germs can be passed from person to person.
- Recognize that bacteria and viruses are microscopic in size and that they cannot be seen with the naked eye.
- Identify behaviors that promote good health.
- Maintain a notebook to document work.
- Share findings and conclusions with others.
- Organize and analyze medical data to determine a likely source of an infection.
- Demonstrate the spread of infection using a graphical organizer and justify connections between infected individuals.
- Follow a step by step method to solve a problem.

## ESSENTIAL QUESTIONS

EQ

1. How can germs be spread from person to person?
2. How does the body defend itself from infectious disease?
3. How can medical professionals use patient symptoms to diagnose illness?
4. How can scientists determine how a germ spreads through a group of people?

## Preparation

- As students work through the design process to develop a solution, use the Summative Rubric to assess their demonstration of learning. A printable version of the rubric is accessible in the Resources section of **Summative Assessment**. Use the rubric as a guide throughout the process of solving the problem.
- Review the **Additional Instructional Resources**. This list includes books that offer diverse perspectives that can expand student understanding. Using these resources provides a sense of inclusion and belonging, and helps students make connections if the content is new to them.

## Problem: Disease Detectives

**120 minutes**

- This problem may be taught over a series of class periods as determined by the teacher and is estimated to take 120 minutes to complete.
- The teacher introduces Problem: Disease Detectives and directs students to access the problem using the device.
- In this problem students are responsible for deducing the chain of infection among the students in the class who are sick.
- The teacher reminds students of the story that sets the stage for the problem. In the project they identified the mystery illness. Now students will work through the design process to solve the problem – outline how the bacteria was passed from student to student.

> **Optional:** Guide students to view the Design Process video before you begin working through the problem.

Students will:

**Ask**

a. The teacher reminds students that the design process can be used to solve many different types of problems in science, technology, engineering, and math.
b. The students review the criteria and constraints of the problem by reading through step 3 in the procedure.
c. The students respond to the following questions in their Launch Logs.
    1. What is the need or want that we are trying to fulfill?
    2. How will you be able to show that you have solved the problem?
d. The teacher guides the students as they complete the self-assessment at the end of the Ask section in their Launch Log.

**Explore**

a. The teacher leads the students through this step of the design process and encourages students to explore all of the data provided about the infection at school.
b. The teacher instructs students to access and analyze the **Evidence Documents** resource sheet as well as information from the Patient Information resource sheet. Answers are provided in the **Tracing the Chain of Infection** answer key. Note that student work may vary.
c. Students take notes about connections between students in the Explore section of their Launch Log.
d. The teacher guides the students as they complete the self-assessment at the end of the Explore section in their Launch Log.

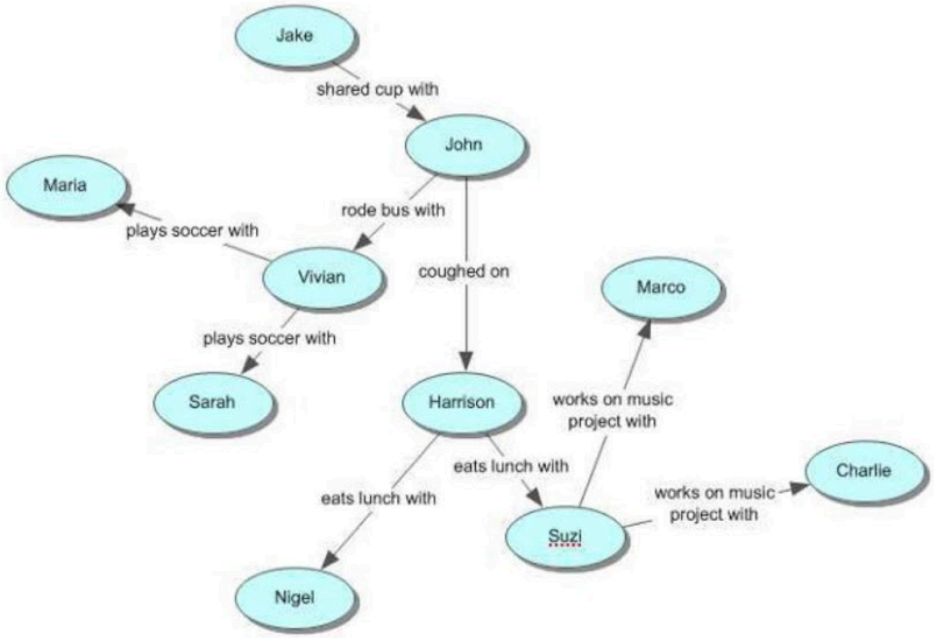
**Model**

a. The teacher leads the students through this step of the design process. Students will decide on a proposed chain of infection and model their solution using Popplet Lite, ShowMe Interactive Whiteboard, or other mind-mapping software. Students can complete a flowchart, web, or other graphic organizer. This graphic must include words that demonstrate the connection between each student in the web.
b. The teacher guides the students as they complete the self-assessment at the end of the Model section in their Launch Log.

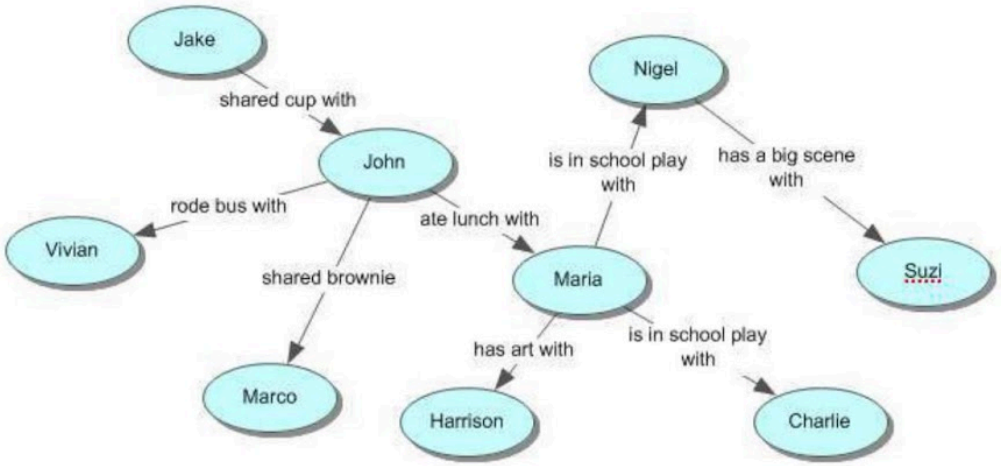
**Evaluate**

a. The teacher leads the students through this step of the design process. Students will write a summary report that describes the information presented in the flowchart or web. This report should evaluate and justify the logic of the solution. Students should make sure to mention specific action or activities that put these students at a greater risk of spreading the streptococcus bacteria. This may include sharing food at lunch, sharing instruments in music class, or sitting in close proximity to someone on a bus.
b. Students will present their proposed solution to the class and answer questions regarding the decisions they have made.
c. Student answers to the problem will vary. Consider all scenarios as long as students justify their chain of infection. Two possible scenarios are described below:

    1. *John contracted strep throat from his brother when he accidentally used his cup. John transferred the bacteria to Harrison and Vivian on the bus. His coughing spread the germs through the air, and his close conversations with Vivian made her an easy target. Vivian plays soccer with Maria and Sarah and most likely transferred strep to them via shared water bottles or close contact. Harrison lunches with Nigel and Suzi, and he could have passed strep to them through his coughs or shared food or drink. Suzi has music class with Marco and Charlie. They have been working on a project together. They may have exchanged germs as they sang or shared instruments.*




2. *John passed the illness to Vivian on the bus. John also lunches with Marco and Maria. He shares his brownie with Marco, offering a direct contact with saliva. Maria may have picked it up as well through conversation or shared utensils. Maria plays soccer with Sarah and most likely passed on strep at practice. Maria has art class with Lily and Harrison. Lily remains unaffected, but Harrison may have contracted the illness during class. Maria also is in the school play with Nigel, Suzi, and Charlie. As they practice lines and sing in close proximity, they all come in contact with the bacteria. Nigel and Suzi have a big scene together.*




d. The teacher guides the students as they complete the self-assessment at the end of the Evaluation section in their Launch Log. The teacher should note that the students only have to complete the "Identify how I can improve" row of this self-assessment.

**Explain**

a. The teacher leads the students through this step of the design process. Students will reflect on what they have learned from this problem in their Launch Log.
b. Students will also provide suggestions for improvement of their solution or their documentation/defense of their solution. They should note why we solve this type of problem. How can pinpointing the chain of infection help limit infection or suggest strategies for prevention?
c. The teacher guides the students as they complete the self-assessment at the end of the Explain section in their Launch Log.

- The Conclusion Questions may be answered individually in the Launch Log or may be discussed in large or small groups.
- Direct students to complete the Infection: Detection Check for Understanding. You can access a printable version of this assessment in the Resources section of the **Summative Assessment** page.

## Conclusion Questions Answer Key

1 How did you evaluate the success of your solution?

Student responses will vary.

2 Because of the outbreak at school, Angelina, Mylo, and Suzi's principal is recommending prevention measures. What measures could the school take to prevent future cases?

Student responses should demonstrate an understanding of communicable diseases. Example response:
*Prevention measures include:*

- *Increased hand washing*
- *Mask wearing*
- *Social distancing*

3 There did not seem to be a high likelihood of passing along the illness in gym class. Why do you think this might have been?

Student responses should demonstrate an understanding of communicable diseases. Example response:
*The illness might not have spread in gym class because students were taking individual fitness tests instead of working in a group. Also, the gymnasium is much larger than the other classrooms, so the students would be farther apart.*

4 Think about what you have learned about communicable diseases. What is one thing you learned that you will use in the future? How might you use it?

Student responses will vary.

Introduction to the Module

# Infection: Modeling and Simulation

Teacher Resources



**Distance Learning Support**

For information about PLTW's distance learning support and online learning guides, jump to Distance Learning Support in **PLTW Launch Module-specific PD Resources**.

For distance learning support for facilitating this module, jump to **Distance Learning Support: Infection: Modeling and Simulation Teacher Guide**.

## PREFACE

**Time**: 10 instructional hours

In this module, students become computer scientists as they explore computer models and simulations. Students research communicable diseases, how they are spread, and how to prevent the spread. Then they simulate the spread of a communicable disease in an unplugged programming activity. They learn that scientists use computer models to test predictions and develop explanations about the spread of these diseases, without infecting real people. Students apply their learning as they use the scientific inquiry process to investigate parameters that prevent the spread of a communicable disease.

After building an understanding of computer models, students create programs using a block-based coding language. Students follow the Use-Modify-Create Framework to learn more about programming. Students use and modify a tutorial to learn how to use conditional statements. Then they build on their programming knowledge to design a computer model that simulates different size populations. Applying knowledge and skills learned from the activities and project, students follow the design process to design a computer model that simulates the spread of a communicable disease.

## TRANSFERS

T

T1 Evaluate a problem in a new and novel situation.
T2 Apply a step-by-step design process to solve a problem.
T3 Analyze a computer model that simulates the spread of a communicable disease.

## ESSENTIAL QUESTIONS

EQ

EQ1 How do computer models and simulations help us to make sense of scientific phenomena?
EQ2 In what ways can computer models and simulations be used to predict outcomes?
EQ3 How can a step-by-step process help you design or improve a solution to a problem?

## UNDERSTANDINGS

U

U1 Scientists and engineers use standard practices to explain the world and solve problems.
U2 A communicable disease is one that can be spread from person to person, or from animal to a person. The spread can occur by direct or indirect contact with an affected individual.
U3 Modeling and simulation allow scientists to test a digital model of a physical system with different parameters to understand and predict how the system behaves in the real world.
U4 Computational thinkers systematically develop solutions through computational methods. The computational methods they use include: breaking down complex problems into simpler parts, gathering ideas or data by combining the efforts of many people or computers, automating solutions through ordered steps, and representing systems through models and simulations.
U5 Mathematical thinkers apply complex thinking and reasoning strategies where thinking is intentional and reflected upon.
U6 Professionals function effectively and efficiently on multidisciplinary teams to be successful.
U7 Professionals communicate effectively with a variety of audiences using multiple modalities to be successful.
U8 Professionals conduct themselves so as to maximize benefits for society and minimize harm.

## LEARNING OBJECTIVES

LO

- LO1.1 Follow a step-by-step method to solve a problem.
- LO1.2 Use scientific reasoning to ask questions, make observations, and investigate ideas to make sense of phenomena and solve problems.
- LO2 Research ways that communicable diseases are spread from person to person.
- LO3 Use computer models to simulate, calculate, and display information about a system.
- LO4 Apply computational thinking strategies to understand and solve problems.
- LO5.1 Apply mathematical thinking to solve problems.
- LO5.2 Apply numbers and operations to solve problems.
- LO6 Collaborate effectively on a diverse and multidisciplinary team.
- LO7 Communicate effectively for specific purposes using the appropriate platform, tool, format, or digital media.
- LO8 Practice ethical behavior in all settings.

## KNOWLEDGE AND SKILLS

KS

- KS1.1.1 Define a simple design problem reflecting a need or a want.
- KS1.1.2 Brainstorm possible solutions to the problem.
- KS1.1.3 Make and use a model to test a design, or aspects of a design, and to compare the effectiveness of different design solutions.
- KS1.1.4 Evaluate a model solution through observations and/or measurements and consider what revisions to the initial model are needed.
- KS1.2.1 Ask and identify questions to gain knowledge or solve problems.
- KS1.2.2 Make observations to draw conclusions of phenomena.
- KS1.2.3 Analyze data to look for patterns or to test whether data are consistent with an initial prediction.
- KS1.2.4 Analyze models as an explanation of phenomena.
- KS2.1 Explain that a communicable disease is contagious, which means a person can spread the infection to others.
- KS2.2 Explain ways communicable diseases are spread from one person to another.
- KS2.3 Identify how the spread of a communicable disease can be slowed down or prevented.
- KS3.1 Identify how computer models are used to simulate real world scenarios.
- KS3.2 Use computer models to predict, collect, and observe data.
- KS3.3 Create a computer model to simulate the spread of a communicable disease.
- KS3.4 Identify the parameters in a simple system.
- KS3.5 Explain that changing a parameter while running a simulation uncovers how the parameter affects the model system.
- KS4.1 Organize and present collected data visually to highlight relationships and support a claim. [CSTA 1B-DA-06]
- KS4.2 Use data to highlight or propose cause-and-effect relationships, predict outcomes, or communicate an idea. [CSTA 1B-DA-07]
- KS4.3 Compare and refine multiple algorithms for the same task and determine which is the most appropriate. [CSTA 1B-AP-08]
- KS4.4 Create programs that use variables to store and modify data. [CSTA 1B-AP-09]
- KS4.5 Create programs that include sequences, events, loops, and conditionals. [CSTA 1B-AP-10]
- KS4.6 Decompose (break down) problems into smaller, manageable subproblems to facilitate the program development process. [CSTA (1B-AP-11]
- KS4.7 Apply a Use-Modify-Create approach to develop programming skills. [CSTA 1B-AP-12]
- KS4.8 Use an iterative process to plan the development of a program by including others' perspectives and considering user preferences. [CSTA 1B-AP-13]
- KS4.9 Test and debug (identify and fix) a program or algorithm to ensure it runs as intended. [CSTA 1B-AP-15]
- KS5.1.1 Make sense of problems and persevere in solving them. [CCSS.MATH.PRACTICE.MP1]
- KS5.1.2 Reason abstractly and quantitatively. [CCSS.MATH.PRACTICE.MP2]
- KS5.1.3 Model with mathematics. [CCSS.MATH.PRACTICE.MP4]
- KS5.1.4 Use appropriate tools strategically. [CCSS.MATH.PRACTICE.MP5]
- KS5.1.5 Look for and express regularity in repeated reasoning. [CCSS.MATH.PRACTICE.MP8]
- KS5.2.1 Read, write, and compare decimals. [CCSS.MATH.CONTENT.NBT.A.3]
- KS5.2.2 Add and divide decimals to calculate the mean. [CCSS.MATH.CONTENT.OA.A.2 and CCSS.MATH.CONTENT.NBT.B.7]
- KS6.1 Generate ideas as a team.
- KS6.2 Value the contributions of each team member.
- KS6.3 Demonstrate collaboration through effective communication.
- KS6.4 Collaborate with others while pair programming. [CSTA 1B-AP-16]
- KS7.1 Document work in an organized notebook.
- KS7.2 Explain findings and justify evidence-based conclusions with others.
- KS7.3 Present data and information accurately and effectively.
- KS8.1 Engage in and maintain positive interactions and relationships with other children and adults.
- KS8.2 Engage in positive, safe, and legal behavior while using the internet and technology.

RESOURCES

R

- Curriculum Framework
- Connections to Standards
- Fifth Grade Connections to Standards
- Family Letter
- Additional Instructional Resources
- Fifth Grade Curriculum Revisions
- Device Specifications
- Application List

# Preparation

## Curriculum Framework and Connections to Standards

Before you facilitate this module, review the Curriculum Framework and Connections to Standards documents.

Standards are the foundation for what is taught in a classroom. They outline what students are expected to learn and be able to do as a result of participating in learning experiences. When planning the implementation of any curriculum, it is essential to identify which standards the curriculum addresses and any standards it does not. This offers greater insight into what the curriculum provides your students and any standards that you may need to address beyond the content provided.

For each PLTW Launch module, teachers are provided a curriculum framework document, which offers a three-stage approach to curriculum planning, assessment, and instruction. The framework document offers a big picture view of the module including the desired results of student learning, assessment opportunities that call for evidence of student learning, and an overview of the scaffolded approach to student learning.

Within the desired results of student learning in the curriculum framework, information is included about module connections to the following standards, when applicable:

- Next Generation Science Standards (NGSS)
- Common Core State Standards (CCSS) in English/Language Arts (ELA) and Mathematics
- Computer Science Teachers Association K–12 Computer Science Standards (CSTA)
- International Society for Technology in Education (ISTE)
- National Association for the Education of Young Children (NAEYC) Early Learning Program Standards
- Head Start Early Learning Outcomes Framework

We understand that your state might not align to these bodies of standards. That is why PLTW Launch is designed for flexible implementation. If your state does not address these standards, spend time comparing your state standards to those identified for the module. Remember that PLTW Launch modules can be implemented at any PreK–5 grade level based on your state standards. Also keep in mind that if you implement a module at a different grade level than indicated, you might need to make modifications to meet the needs of your students.

Exploring this framework resource before you examine the Teacher Guide gives you a high-level understanding of the stages to curriculum planning, assessment, and instruction. You can also determine how the module connects to the required standards for your state. After you have explored the curriculum framework document, you'll be ready to explore the step-by-step instructions in the Teacher Guide.

## Professional Development PD

### Resources

Before you facilitate the Infection: Modeling and Simulation module, review the professional development resources.

- Access the **Launchpad** to review:
  - Three Dimensional Learning
  - Claims and Evidence
  - The Teacher as Facilitator
  - PLTW Formative Assessment
  - Using PLTW Launch Logs
  - Uncovering and Addressing Misconceptions
  - The APB Instructional Approach
  - Setting the Stage for APB Learning
  - Thinking Like an Engineer
  - Developing Research Skills with Elementary Students
  - The Design Process Song: Version 1
  - The Design Process Song: Version 2
- Access the **Infection: Modeling and Simulation Module-specific PD Resources** to review:
  - Infection: Modeling and Simulation APB Overview
  - Infection: Modeling and Simulation Module Introduction

### Questioning Skills

As you facilitate APB learning, asking probing questions is essential. Within each activity, project, and problem throughout this Teacher Guide, you will notice sample prompts to ask your class. The prompts guide you to ask thought-provoking questions, as well as to identify conceptions and misconceptions.

As you work with your students, remember that you are not limited to the prompts provided. The best way to determine the types of questions to ask your students comes from observing and interacting with your students as they engage in the module. This provides formative assessment of students' conceptual development and allows you to uncover and address misconceptions.

Building your questioning skills increases your capacity to facilitate powerful student learning. For more information, review the following professional development resources in the **Launchpad**:

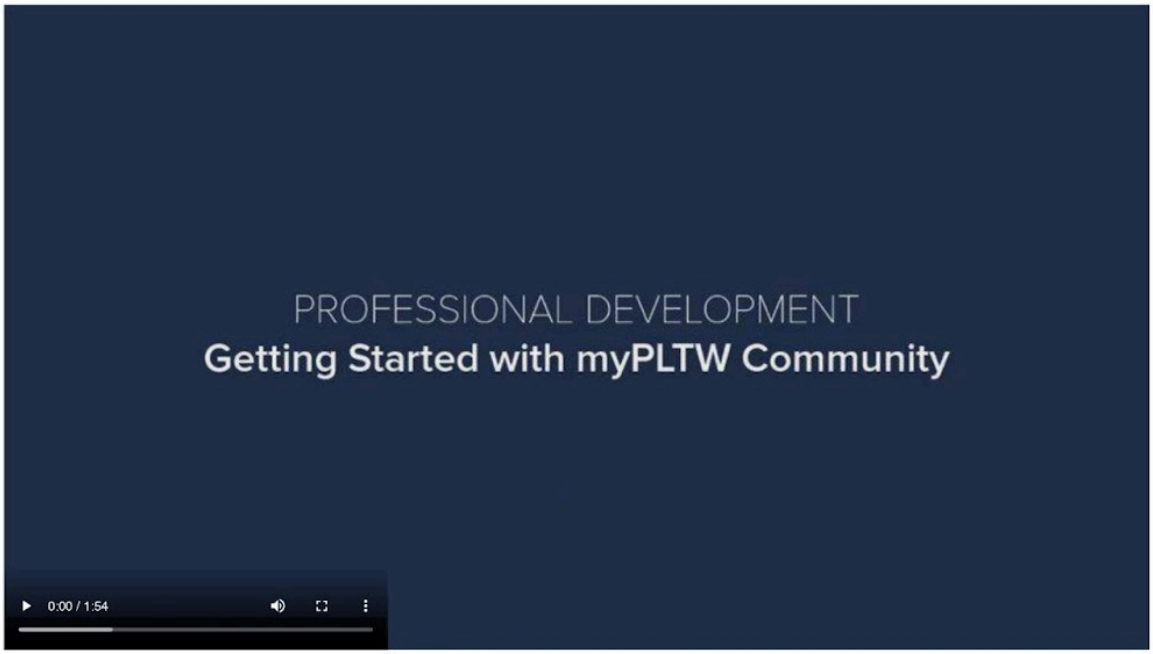
- The Art of Questioning

- Building Your Questioning Skills

## Community

As a PLTW Launch Classroom teacher, you are enrolled in discussion groups that allow you to network with other teachers. These discussion groups are in the Community tool in myPLTW. In these groups, you can communicate with other teachers about topics such as general information, modules, and equipment and software. You also have the opportunity to share success stories.

Before you facilitate a module, it is a good idea to review the posts in the groups to gather helpful information from teachers who have previously taught the module. If you have specific questions or comments to make, these discussion groups are a great way to connect with the PLTW Launch network.




Getting Started with myPLTW Community video

## Family and Community Relationships

Family and community relationships are encouraged throughout the module. A **Family Letter** is provided to introduce Project Lead The Way to families, ask for donations to complete specific activities, projects, or problems, and encourage families to support students' learning of concepts at home. PLTW recommends that you send this letter to families before you begin a module, to let them know what their students will be learning in school. A section titled "Dealing with Misconceptions" is also provided in the letter, so families can gain an understanding of the concepts introduced within the module.

FAMILY CONNECTION

Throughout the module, each activity, project, and problem includes a Family Connection section identified by this house icon. These sections provide activities families can do to support what students are learning. Families can use the log-in information provided in the Family Letter to access the course activities.

Consider ways in which you can establish community relationships throughout the Infection: Modeling and Simulation module. To encourage career connections in the classroom, you could invite speakers, such as doctors, engineers, analysts, data scientists, and IT professionals, to talk about communicable disease, coding, and simulations in their work.

**Tip**: Prepare visitors for ways to best work with young children, such as:

- Bring items for students to touch
- Use visuals
- Keep dialogue short and simple
- Introduce new terms

## PLTW Launch Logs

As students progress through each module, they use PLTW Launch Logs to record their thinking, ideas, observations, and designs. The PLTW Launch Log is not a traditional workbook nor a collection of worksheets; rather it's designed to be an age-appropriate version of an engineering notebook. In the PLTW Launch Logs, students document their learning as they draw and write their ideas.

As the teacher, you can easily use this record of student ideas for formative assessment by evaluating students' demonstrations of their thinking and conceptual understanding. Allowing students to explain the thinking behind their responses to prompts is an invaluable way to uncover misconceptions and guide students to conceptual understanding. To gain a deeper understanding of the purpose and use of PLTW Launch Logs, access the "Using PLTW Launch Logs" professional development resource in the **Launchpad**.

## Developing Vocabulary

Vocabulary learning has been found most effective when active engagement with a term goes beyond just knowing the definition. Rather than presented in isolated lessons, vocabulary is introduced within the context of the activities, project, and problem. Viewing the course on a digital device, students have as-needed access to a glossary and interactive flashcards. Each card has an audio component, so students can independently review these words throughout the module.




0:00 / 0:07

## Icon Legend

Throughout the Teacher Guide, the following icons have special meanings.

### Digital Device

The Digital Device icon indicates times when you or your students will use a device for a learning experience.

### Professional Development

The Professional Development (PD) icon indicates when a resource is available to provide additional information to you as a teacher. You can find these resources in the PLTW Launch Module-specific PD Resources course.

## Additional Instructional Resources

Project Lead The Way understands the importance of introducing literature, music, and rhyme to students. As such, we created a list of **Additional Resources** specific to this module. These resources are not included in the equipment kit, and they are not covered in the 10 instructional hours of the module. Incorporating the resources is optional, but they offer ways to provide additional engagement with the concepts explored in this module.

## Curriculum Revisions

The Launch curriculum is continuously updated to provide content and instructional resources that are current and based on best practices. Significant revisions to the curriculum implemented since the prior release of Launch are documented in the **Fifth Grade Curriculum Revisions**.

Each activity, project, and problem within this module is new. See **Infection: Modeling and Simulation Updates** for more details.

Introduction Story

# Understanding the Spread

Teacher Resources

View Student Course

RESOURCE

R

Introduction Story: Understanding the Spread

**Time**: 20 Minutes

## Introduction

To set the stage for learning, guide students to read the Introduction Story: *Understanding the Spread*, a fictional story that introduces the problem. You may print the story if needed.

1. Introduce students to the student course and assist them with the log-in process on a digital device. For the rest of the module, students will access the curriculum in the student course.
2. Guide students to access the Introduction Story: *Understanding the Spread.* Students can read or listen to the story using audio in small groups. Alternatively, you may read the story aloud as a class.
3. Use the guiding questions within the story to engage students in thinking about ideas and concepts throughout the module. Use this time of discussion to uncover what your students already know about the concepts, what they are curious about, and what misconceptions they have. Consider how this formative assessment of students can guide you as you facilitate the activities, project, and problem in this module.
4. To set the purpose for the learning experiences to come, it is important to guide students to identify the problem. Throughout the module, students can reread the story to remind themselves of the problem they will be solving.

Activity 1

# Communicable Disease Exploration

Teacher Resources

View Student Course

## EQUIPMENT

This list is based on a class of 30 students.

| Not Included in Equipment Kit | Device Applications |
|---|---|
| • Grades 3–5 PLTW Launch Logs (1 per student)<br>• Digital devices<br>• Red construction paper (8 pieces)<br>• Blue construction paper (8 pieces)<br>• Glue<br>• Pencils or colored pencils for sketching | • Inkling<br>• Digital product apps, such as:<br>  ◦ Popplet Lite<br>  ◦ Mindomo<br>  ◦ ShowMe Interactive Whiteboard<br>  ◦ iMovie<br>  ◦ Quik<br>  ◦ Kapwing<br>  ◦ Video function on device |

## RESOURCES

R

- Grades 3–5 Launch Log
- Research Resources
- Stay Safe and Secure!
- Disease Simulation

## ESSENTIAL QUESTIONS

EQ

EQ1 How do computer models and simulations help us to make sense of scientific phenomena?
EQ2 In what ways can computer models and simulations be used to predict outcomes?
EQ3 How can a step-by-step process help you design or improve a solution to a problem?

## LEARNING OBJECTIVES

LO

LO1.2 Use scientific reasoning to ask questions, make observations, and investigate ideas to make sense of phenomena and solve problems.
LO2 Research ways that communicable diseases are spread from person to person.
LO4 Apply computational thinking strategies to understand and solve problems.
LO6 Collaborate effectively on a diverse and multidisciplinary team.
LO7 Communicate effectively for specific purposes using the appropriate platform, tool, format, or digital media.
LO8 Practice ethical behavior in all settings.

| KNOWLEDGE AND SKILLS | KS |
|---|---|
| KS1.2.2 | Make observations to draw conclusions of phenomena. |
| KS1.2.3 | Analyze data to look for patterns or to test whether data are consistent with an initial prediction. |
| KS1.2.4 | Analyze models as an explanation of phenomena. |
| KS2.1 | Explain that a communicable disease is contagious, which means a person can spread the infection to others. |
| KS2.2 | Explain ways communicable diseases are spread from one person to another. |
| KS2.3 | Identify how the spread of a communicable disease can be slowed down or prevented. |
| KS4.1 | Organize and present collected data visually to highlight relationships and support a claim. [CSTA 1B-DA-06] |
| KS4.2 | Use data to highlight or propose cause-and-effect relationships, predict outcomes, or communicate an idea. [CSTA 1B-DA-07] |
| KS6.1 | Generate ideas as a team. |
| KS6.2 | Value the contributions of each team member. |
| KS6.3 | Demonstrate collaboration through effective communication. |
| KS7.1 | Document work in an organized notebook. |
| KS7.2 | Explain findings and justify evidence-based conclusions with others. |
| KS7.3 | Present data and information accurately and effectively. |
| KS8.1 | Engage in and maintain positive interactions and relationships with other children and adults. |
| KS8.2 | Engage in positive, safe, and legal behavior while using the internet and technology. |

# Preparation

## Professional Development

Before you facilitate Activity 1, review the professional development resources.

- Access the **Launchpad** to review Developing Research Skills with Elementary Students.
- Access the **Infection: Modeling and Simulation Module-specific PD Resources** to review:
  - Building Your Understanding: Germs
  - Building Your Understanding: Stopping the Spread
  - Integrating Technology and Promoting Online Safety

## Part 1. Introduction and Research

1. Before you begin Activity 1, read the **Introduction Story: *Understanding the Spread*** with students.
2. To become familiar with the content, preview the student resource, "What Are Communicable Diseases?" Review the discussion questions provided in the Procedure.
3. In Part 1, students research communicable diseases. It is important that you address misconceptions about these diseases, including their symptoms, how they are spread, and who can be infected by the diseases.

> **Note**: Students develop misconceptions about diseases from the media and conversations with others. Misconceptions can come from not having relevant factual information.
>
> Examples of misconceptions are:
> - **COVID-19 does not infect children**. COVID-19 can infect anyone regardless of their age, race, gender, or socioeconomic status.
> - **Ebola infects only Black people**. Ebola can infect anyone. Nothing medically differentiates vulnerability to it of any race.

4. Divide students into eight groups. Assign each group of students one communicable disease to research, so each disease is represented from the following list:
   - Common cold
   - Strep throat
   - Measles
   - Influenza (flu)
   - Chicken pox
   - Pertussis (whooping cough)
   - Pink eye (conjunctivitis)
   - Ebola
5. Review the **Research Resources**. Select books, websites, articles, and other material students can use to do research on communicable diseases.
6. Optional: Review the **Staying Safe and Secure** interactive experience. Decide whether you would like students to view this resource about staying safe online and engaging in positive interactions with others before they begin their online research. If desired, print off the Stay Safe and Secure! resource for students to place in their PLTW Launch Logs.

## Part 2. Disease Simulation

Review the directions and complete the preparation for the **Disease Simulation**.

> **Time**: 80 Minutes

# Introduction

In this activity, students learn about *communicable diseases* and how they are spread from one person to another. They activate their prior knowledge of how to prevent the spread of these *contagious* illnesses, including actions such as washing our hands, covering our mouth when we cough or sneeze, and social distancing. In small groups, they research one *communicable disease*, how it is spread, and how to prevent the spread. They present their findings to the class through a digital presentation.

Students apply what they learned to act out a *simulation* that mimics the spread of a *communicable disease* in the classroom. They consider how changing *parameters* in the *simulation*, such as the initial number of *infected* students, impacts the final number of *infected* students.

| | |
|---|---|
| communicable disease | An infectious disease that can spread from one organism to another. |
| contagious | Able to be passed from one organism to another. |
| disease outbreak | A sudden increase in the number of organisms infected with a disease. |
| germ | A microorganism that can make a person sick. |
| infected | Having a disease caused by germs. |
| infectious disease | An illness caused by germs that harms an organism's health. |
| organism | A living thing. |
| parameter | A value that helps to define how a computer model works in a simulation. Parameters can be changed for each simulation to show how the parameter affects the model. |
| simulation | Using a computer model to see a situation happen, without testing it in real life. |
| susceptible | Capable of becoming infected by a disease. |
| variable | Something that changes or can be changed. |

### Possible Student Misconceptions

- **Having close contact with someone with a communicable disease means that you automatically and immediately catch that disease**. The common cold is very contagious and easily spreads from person to person through the air without the need for physical contact. However, catching a communicable disease is not automatic but depends on multiple factors. Microbes that enter the bloodstream to cause disease may not be enough to cause the full-blown infection, or the body's immune system may be able to fight them off. So a person can come into close contact with a person who has a disease and not catch it. For extremely infectious or potentially harmful infections, isolation is recommended.
- **You can only catch a cold if you are exposed to wet and cold conditions**. While you may have heard that you need to protect yourself from cold or wet conditions to avoid being sick, this is not how infections spread. The common cold is caused by a virus and is spread by being in proximity to an infected person.
- **A vaccination is given to cure a communicable disease**. Children may confuse prevention and treating diseases. Vaccinations are given to healthy individuals to help prevent future illness by stimulating the production of antibodies.
- **Diseases infect certain groups of people**. Race, gender, and socioeconomic status are not factors in the infection of communicable diseases. Some people may be more impacted by a disease because of inequity in resources, but anyone could be infected if they are exposed.

## Procedure

### Part 1. Introduction and Research

1. Direct students to access Activity 1 in the student course and have them read the Introduction.
2. Students use PLTW Launch Logs to keep a record of their work as they progress through the module. Distribute a Grades 3–5 Launch Log to each student. In their notebooks, they can take notes as they research, create sketches, and answer conclusion questions.
3. Have students prepare their PLTW Launch Logs for Activity 1.
4. Guide students to complete a Think-Pair-Share on the following questions about a time they have been sick in the past:
   - What symptoms did you have?
   - Could the illness be passed to someone else? Why or why not?
   - What did you do to prevent others from getting sick?

   **Note**: Think-Pair-Share is a strategy where students think individually, discuss ideas with a partner, and then share with the whole class. It increases participation and focus.
5. Introduce infectious diseases. Tell students, if the illness they discussed could be passed to someone else, that means it is contagious and is a communicable disease. Direct students to access the flashcard examples as you introduce the vocabulary terms *infectious disease*, *contagious*, and *communicable disease*.
6. Direct students to read the resource, "What Are Communicable Diseases?" to learn information about how diseases are spread. Direct students to answer the questions in the Procedure in their Launch Logs while they read.
7. Lead a discussion about the resource.

   - How are communicable diseases spread?
   - How can we prevent or control the spread of a communicable disease?

8. Tell students which communicable disease they will research. Have them record the name of the disease as a header in their Launch Log.
9. Direct students to read the description of their disease and document the symptoms in their Launch Log.
10. Guide students to work in a small group to conduct research on their communicable disease. See **Research Resources** for research options.

**Optional: Internet Safety**

1. Guide students to view the **Staying Safe and Secure** interactive experience with a partner or small group.

> **Note**: As students review the Staying Safe and Secure interactive experience, you have the opportunity to address misconceptions students have about the internet and the world wide web. It also provides an opportunity for you to define terms and rules for students based on your school's specific policies and practices.

2. Lead a discussion about the interactive experience.

- How does the internet benefit people?
- In what ways do you use the internet at school?
- How would your life be impacted if you did not have access to the internet? Explain your thinking.
- Why is it important to have a strong password on your devices and accounts? Use evidence from the interactive experience to support your answer.
- What is the difference between bullying and cyberbullying? Why do you think that?
- In what ways could you be impacted by posting inappropriate content online? Explain your thinking.

11. Have students record their research findings in their Launch Logs to answer the following questions:
    - How is the communicable disease spread?
    - How can we prevent or control the spread of the communicable disease?
12. Direct students to create a digital presentation to share their findings with the class, including:
    - Name of the disease
    - Symptoms
    - How it is spread
    - How to prevent or control the spread
13. Allow time for students to share their digital presentations.
14. After all the presentations, lead a discussion about the spread of communicable disease.

- What makes an infectious disease communicable?

  An infectious disease is communicable when it is contagious, or can be spread from person to person.

- In what ways are communicable diseases spread from one person to another?

  Responses may include:
  - Shaking hands
  - Coughing and sneezing
  - Contaminated surfaces
  - Bites from an insect

- In what ways can the spread of communicable diseases be prevented or controlled?

  Responses may include:
  - Handwashing
  - Cleaning surfaces
  - Staying home when you are sick
  - Avoiding touching your eyes, nose, or mouth

## Part 2. Disease Simulation

15 Introduce simulations. In Part 1, students learned that disease outbreaks of communicable diseases can have a large, negative impact on human health. To prepare for outbreaks, scientists use simulations to predict the spread of the disease and provide resources to people who need it. Direct students to access the flashcard example to introduce the vocabulary term *simulation*.

16 Introduce the Disease Simulation. For step-by-step directions, see **Disease Simulation**. Explain to students that they will model what scientists would do to simulate the spread of a communicable disease.

17 Complete the four rounds of the simulation to see the effects of the spread when coming into contact with others.

18 Lead a discussion about the simulation.

- How did changing the number of initial infected students affect the final number of infected students?
  - Increasing the number of initial infected students increases the final number of infected students.
  - Decreasing the number of initial infected students decreases the final number of infected students.
- How did changing the number of contacts between students affect the final number of infected students?
  - Increasing the number of contacts between students increases the final number of infected students.
  - Decreasing the number of contacts between students decreases the final number of infected students.

19 Explain to students that simulations use parameters and variables to collect and analyze data to make decisions. Direct students to access the flashcard examples to introduce the vocabulary terms *parameter* and *variable*.

20 Direct students to discuss with their groups what they think the parameter(s) and variable(s) were in the Disease Simulation.

21 Guide students to label their Health Status chart with the parameters and variable for this simulation.

**Parameters**: These values were determined at the beginning of each simulation, and they affected the data that was collected.
- Initial number of infected students
- Number of contacts

**Variable**: This value helped us make sense of the simulation and explained its results.
- Final number of infected students

| Health Status | | | |
|---|---|---|---|
| Round | Parameter: Initial number of infected students | Parameter: Number of contacts | Variable: Final number of infected students |
| 1 | 3 | 3 | |
| 2 | 6 | 3 | |
| 3 | 3 | 6 | |
| 4 | 6 | 6 | |

22 Guide students to answer the Conclusion Questions. Lead a discussion for students to share their thoughts.

## Conclusion Questions Answer Key

**Note**: Conclusion Questions offer an opportunity for formative assessment. You may use them as a whole-class discussion or you may have students record ideas in their Launch Logs.

1 In the disease simulation, you had direct contact with classmates to simulate the spread of a communicable disease. What actions could you take to prevent the spread of a disease that is passed through direct contact with others?

Student responses should demonstrate an understanding of preventing the spread of a communicable disease. Example response:
If the communicable disease is passed by direct contact, I could prevent the spread of it by washing my hands often, using hand sanitizer, and avoiding touching my eyes, nose, and mouth.

2 How do parameters impact the results of a simulation? How could scientists use these parameters to predict the spread of a communicable disease? Use evidence from the activity to explain your thinking.

Student responses should demonstrate an understanding of communicable diseases and simulations. Example response:
Parameters change the results of a simulation. For example, in the Disease Simulation, one of the parameters we changed was the number of contacts. When there were more contacts, more students were infected. When there were fewer contacts, fewer students were infected. The different parameters could help scientists make decisions about how to prevent further spread of the communicable disease, such as limiting contact with others.

Activity 2

# Playing with Parameters

Teacher Resources

View Student Course

## EQUIPMENT

The list below is based on a class of 30 students.

| Not Included in Equipment Kit | Device Application |
|---|---|
| • Grades 3–5 PLTW Launch Logs (1 per student)<br>• Digital devices<br>• Pencils or colored pencils for sketching<br>• Chart paper<br>• Marker | • Inkling<br>• ShowMe Interactive Whiteboard |

## ESSENTIAL QUESTIONS

EQ

EQ1 How do computer models and simulations help us to make sense of scientific phenomena?
EQ2 In what ways can computer models and simulations be used to predict outcomes?
EQ3 How can a step-by-step process help you design or improve a solution to a problem?

## LEARNING OBJECTIVES

LO

LO1.2 Use scientific reasoning to ask questions, make observations, and investigate ideas to make sense of phenomena and solve problems.
LO2 Research ways that communicable diseases are spread from person to person.
LO3 Use computer models to simulate, calculate, and display information about a system.
LO4 Apply computational thinking strategies to understand and solve problems.
LO5.1 Apply mathematical thinking to solve problems.
LO5.2 Apply numbers and operations to solve problems.
LO6 Collaborate effectively on a diverse and multidisciplinary team.
LO7 Communicate effectively for specific purposes using the appropriate platform, tool, format, or digital media.
LO8 Practice ethical behavior in all settings.

## KNOWLEDGE AND SKILLS

KS

| | |
|---|---|
| KS1.2.1 | Ask and identify questions to gain knowledge or solve problems. |
| KS1.2.2 | Make observations to draw conclusions of phenomena. |
| KS1.2.3 | Analyze data to look for patterns or to test whether data are consistent with an initial prediction. |
| KS1.2.4 | Analyze models as an explanation of phenomena. |
| KS2.1 | Explain that a communicable disease is contagious, which means a person can spread the infection to others. |
| KS2.2 | Explain ways communicable diseases are spread from one person to another. |
| KS2.3 | Identify how the spread of a communicable disease can be slowed down or prevented. |
| KS3.1 | Identify how computer models are used to simulate real world scenarios. |
| KS3.2 | Use computer models to predict, collect, and observe data. |
| KS3.4 | Identify the parameters in a simple system. |
| KS3.5 | Explain that changing a parameter while running a simulation uncovers how the parameter affects the model system. |
| KS4.1 | Organize and present collected data visually to highlight relationships and support a claim. [CSTA 1B-DA-06] |
| KS4.2 | Use data to highlight or propose cause-and-effect relationships, predict outcomes, or communicate an idea. [CSTA 1B-DA-07] |
| KS5.1.1 | Make sense of problems and persevere in solving them. [CCSS.MATH.PRACTICE.MP1] |
| KS5.1.2 | Reason abstractly and quantitatively. [CCSS.MATH.PRACTICE.MP2] |
| KS5.1.3 | Model with mathematics. [CCSS.MATH.PRACTICE.MP4] |
| KS5.1.4 | Use appropriate tools strategically. [CCSS.MATH.PRACTICE.MP5] |
| KS5.1.5 | Look for and express regularity in repeated reasoning. [CCSS.MATH.PRACTICE.MP8] |
| KS5.2.1 | Read, write, and compare decimals. [CCSS.MATH.CONTENT.NBT.A.3] |
| KS5.2.2 | Add and divide decimals to calculate the mean. [CCSS.MATH.CONTENT.OA.A.2 and CCSS.MATH.CONTENT.NBT.B.7] |
| KS6.1 | Generate ideas as a team. |
| KS6.2 | Value the contributions of each team member. |
| KS6.3 | Demonstrate collaboration through effective communication. |
| KS7.1 | Document work in an organized notebook. |
| KS7.2 | Explain findings and justify evidence-based conclusions with others. |
| KS7.3 | Present data and information accurately and effectively. |
| KS8.1 | Engage in and maintain positive interactions and relationships with other children and adults. |
| KS8.2 | Engage in positive, safe, and legal behavior while using the internet and technology. |

## Preparation

### Professional Development

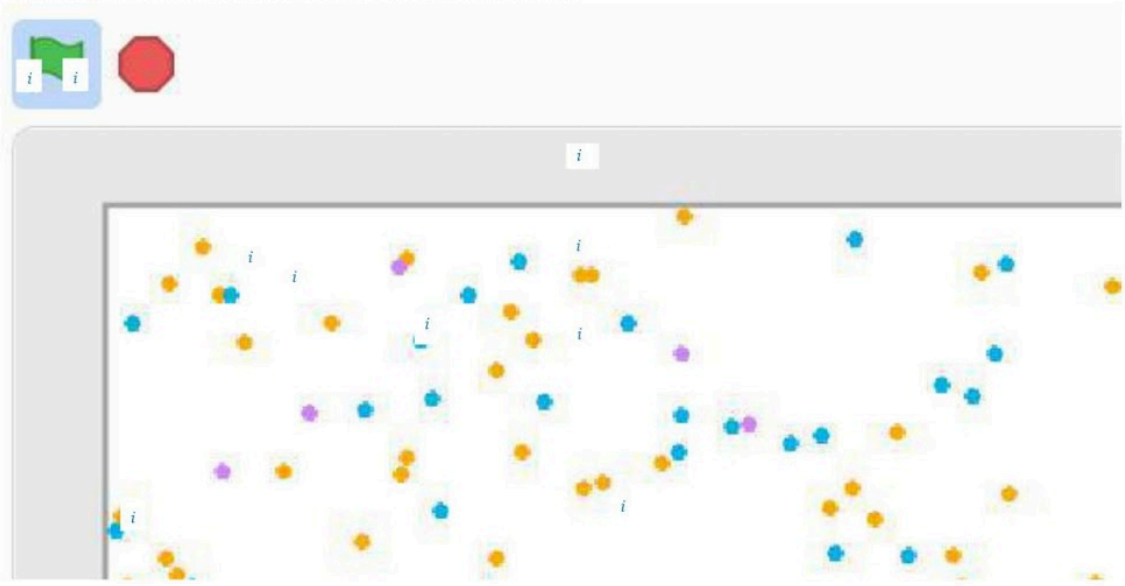
Before you facilitate Activity 2, access the **Infection: Modeling and Simulation Module-specific PD Resources** to review Building Your Understanding: Computer Models and Simulations.

### Activity 2

1. In this activity, students use the Scientific Inquiry Process. This process is similar to the design process, but there are distinct differences. The Scientific Inquiry Process:
   - Is brought into PLTW Launch modules to provide exposure and experience for students to think and work scientifically.
   - Is included in the modules whenever students need to collect data and answer testable questions.
   - Helps students learn how to approach a testable question and set up an experiment to collect the necessary data.

> **Testable Questions**
>
> In the Ask step of the Scientific Inquiry Process, students brainstorm testable questions about a topic. A testable question is one that can be answered by designing and conducting an experiment or investigation. It needs to be specific enough so that you test only one variable at a time to draw conclusions. The answers to a testable question can be observed and measured. Examples of testable questions:
> - What happens to mass when two substances are mixed together?
> - What happens when you mix red, blue, and green colored light in different combinations?
> - Do plants need sunlight to grow?
> - What affects the brightness of a star in our night sky?

2. Review the Communicable Disease simulation before you present it to students.



Communicable Disease Simulation image

   - Explore the features of the computer model. Click the information icons in the image to familiarize yourself with how to use the simulation and understand the data.




- Explore the features of the simulation.
  - To start the simulation, select the green flag.
  - Select the No Prevention, Staying Home, and Washing Hands parameters.
  - See the colors of the dots change from orange (susceptible), to blue (infected), to purple (recovered) for each parameter.
  - Observe the change in values for Susceptible, Infected, and Recovered individuals for each parameter.
  - Watch the graph change throughout the simulation.

> **Note**: The computer model is programmed to run each simulation for one minute.

**Time**: 100 Minutes

## Introduction

In this activity, students apply their knowledge about how *communicable diseases* can be spread as they learn how *computer models* are used to *simulate* the spread. With a *computer model*, students explore how *parameters* are used to impact the spread across a large population of people. Using the *scientific inquiry process*, students make predictions about how staying home, washing your hands, and taking no prevention impacts the number of *infected* people. They record their data and support their claims with evidence.

| | |
|---|---|
| communicable disease | An infectious disease that can spread from one organism to another. |
| computer model | A computer program that is designed to simulate what might happen or what did happen in a situation. |
| contagious | Able to be passed from one organism to another. |
| infectious disease | An illness caused by germs that harms an organism's health. |
| parameter | A value that helps to define how a computer model works in a simulation. Parameters can be changed for each simulation to show how the parameter affects the model. |
| scientific inquiry process | A process that scientists use to explore observations and answer questions. |
| simulation | Using a computer model to see a situation happen, without testing it in real life. |

### Possible Student Misconception

- **Simulations are 100% accurate**. Simulations are simplified representations of reality; they cannot predict the future. For example, simulations were used to help make decisions for the COVID-19 pandemic at its onset. At the time, however, it was not clear how the disease could spread from one person to another. Over time the simulations of the disease will become more accurate, but the impact of the spread is not possible to predict with 100% certainty, given varying factors in a population such as age, health, use of transportation, and others.

## Procedure

1. Direct students to access Activity 2 in the student course and have them read the Introduction.

2. Have students prepare their PLTW Launch Logs for Activity 2.
3. Lead a discussion about Activity 1.

- What is a communicable disease?
  Direct students to access the flashcard examples as you review the vocabulary terms *communicable disease*, *infectious disease*, and *contagious*.
- How are communicable diseases spread from one person to another?
- What are some ways that we can prevent or control the spread of communicable diseases?
- In what ways can we predict how a communicable disease will spread?
  Direct students to access the flashcard example to review the vocabulary term *simulation*.

4. Talk to students about the Disease Simulation they completed in Activity 1.
   - Sample size is the total size of the population studied in a scientific investigation. This simulation used a small sample size (number of students in your class).
   - If a sample size is too small, it can lead to unreliable results.
5. Introduce how scientists use computer models to predict more reliable results. Computer models run simulations that mimic how communicable diseases are spread. Scientists use them to predict the spread because computer models:
   - Are ethical. They do not infect real people.
   - Can simulate parameters. This lets you see the impact of different prevention strategies on controlling the spread of an illness.
   - Simulate the spread across large groups of people—even the entire global population!
   - Can run simulations multiple times to get more accurate data.

   Direct students to access the flashcard examples to introduce the vocabulary terms *computer model* and *parameter*.
6. Introduce the Communicable Disease investigation. In this investigation, students will use a computer model to simulate how parameters, such as washing your hands and staying home, impact the spread of a communicable disease.
7. Explore students' ideas about the work of scientists. Lead them to understand that scientists are people who ask questions, make observations, and investigate ideas, to acquire knowledge and/or solve problems. Tell students that they are now going to act as scientists to learn more about computer models and simulations.

- What do you think scientists do?
- Why do you think this?

8. Guide students to view the Scientific Inquiry Process video as an introduction to scientists and the scientific inquiry process.




Scientific Inquiry Process video

9. Lead a discussion about what students learned from the Scientific Inquiry Process video.

- Why do scientists use the scientific inquiry process?
  Direct students to access the flashcard example as you review the vocabulary term *scientific inquiry process*.
- How do you think the scientific inquiry process helps scientists in their work?
- Why is it important to ask questions as you work through the scientific inquiry process? Why do you think that?
- What makes a question testable? What are some testable questions you have investigated in the past?

10 **Ask**: Direct students to work with a small group to brainstorm questions they could investigate about the spread of communicable diseases.

- Allow time for each group to share some of their ideas with the class. Ask students to share ideas for how you would test questions like those they have presented.
- Present the questions for this investigation:
  - Which parameter will result in the least number of infected people: No Prevention, Staying Home, or Washing Hands?
  - Which parameter will result in the greatest number of infected people: No Prevention, Staying Home, or Washing Hands?
- Have students record the testable questions in their Launch Logs.

11 Guide students to view the annotated image in the student procedure. Be sure students understand the three parameters that this simulation will explore: No Prevention, Staying Home, and Washing Hands.

12 Direct students to access the flashcard examples to review the vocabulary terms *variable*, *susceptible*, and *infected*. Direct students to access the flashcard example to introduce the vocabulary term *recovered*.

> **Note**: The numbers of Susceptible, Infected, and Recovered people are the variables used to collect data in this computer model. These numbers change throughout a simulation.

13 **Predict**: Guide students to make predictions to answer the testable questions for this investigation.

- Direct students to record their predictions in their PLTW Launch Logs about the parameters that will lead to the greatest and least number of infected people.
- Remind students that their predictions should be based on their past experiences and prior knowledge.
- Lead a discussion about the questions for this investigation.

- Which parameter do you think will result in the least number of infected people: No Prevention, Staying Home, or Washing Hands?
- Which parameter do you think will result in the greatest number of infected people: No Prevention, Staying Home, or Washing Hands?
- How do you think we can use a simulation to test these questions?

14 Guide students to draw the Sum of Infected and Recovered People chart in their Launch Logs. Explain that in this investigation, they need to calculate the total number of individuals infected by the communicable disease. To do so, they will need to find the sum of the infected and recovered people at the end of each simulation.

| Sum of Infected and Recovered People | | | |
|---|---|---|---|
| Trial | No Prevention | Staying Home | Washing Hands |
| 1 | | | |
| 2 | | | |
| 3 | | | |
| Mean (Average) | | | |

15 Model how to use the Communicable Disease simulation. Be sure students know how to:

- Start and stop the simulation
- Select and run each parameter
- Identify the number of susceptible, infected, and recovered people
- Calculate the sum of infected and recovered people when running a simulation

16 **Investigate**: Guide students to run the simulation for each parameter three times. As students complete the investigation, circle around the room and assess student progress. Ask students to share their ideas and thinking with you as they work. As you uncover misconceptions, work with students to use the investigations to build accurate conceptual understanding.

17 **Observe**: Direct students to record their results in their chart. Guide students to calculate the average number of infected individuals by adding the values in each column and divide the sum by the number of trials (3). If necessary, review how to find the average with students.

> **Note**: Due to the inherent randomness built in to the program, each simulation run may yield different results.

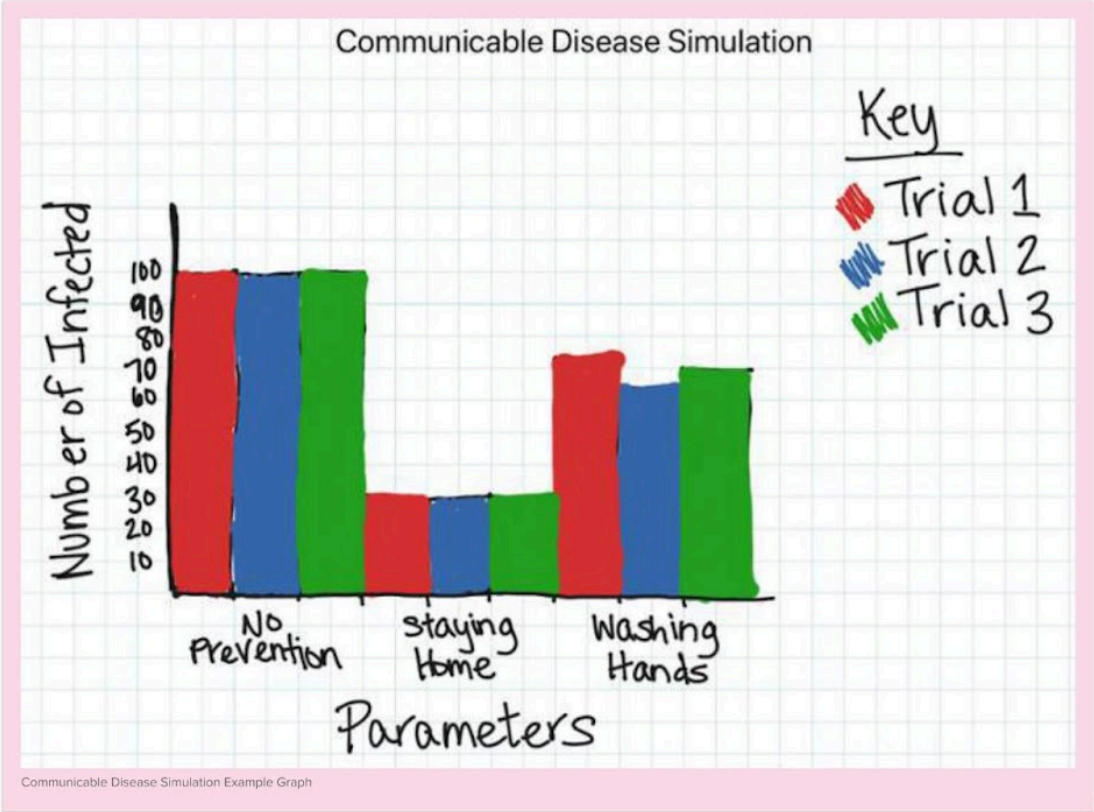
18 **Explain**: Direct students to discuss their findings in their small groups. They consider:

- What observations did you make when you ran the No Prevention parameter? Staying Home parameter? Washing hands parameter?

- Were your predictions correct? Why or why not?
- What surprised you about the outcomes of the investigation?

19 Model how to create a bar graph with the data from the investigations. Use a piece of grid chart paper or the ShowMe Interactive Whiteboard app to create the graph. Guide students to create a graph in their Launch Logs while you model.

- Write "Communicable Disease Simulation" as the title.
- Draw x- and y-axes on the grid.
- Label the y-axis "Number of Infected".
- Label the x-axis "Parameters".
- Create a color key for Trial 1, Trial 2, and Trial 3.




Communicable Disease Simulation Example Graph

20 Direct students to record the data from their investigation of the three parameters to their graphs.

21 Lead a discussion about computer models and simulations.

- What did you notice about the average number of infected people for each parameter?
- What did you notice about the number of infected people for each trial? Were they the same or different?

Because many factors can affect the spread of communicable diseases, the simulation used in this activity has some randomness resulting in a different number of infected people for each trial.

- Why do you think it is important to run multiple trials when using simulations?

Running simulations several times allows scientists to be sure the results are consistent.

- Why do scientists use simulations to understand the spread of communicable diseases? Use evidence from the activity to explain.

Because communicable diseases can be harmful to humans, it is not ethical to test how they spread to living people. Instead, simulations are used to allow testing of many parameters with large groups of people.

- How could scientists use the data you collected from each parameter to make decisions about preventing a communicable disease?

With the simulation in this activity, a scientist may use the data to determine that to best prevent the spread of the communicable disease, infected individuals should stay home.

22 Guide students to answer the Conclusion Questions. Lead a discussion for students to share their thoughts.

## Conclusion Questions Answer Key

1 Compare the simulation in this activity to the one you used in Activity 1. What are the benefits of using the computer model?

Student responses should demonstrate an understanding of computer models and simulations. Example response:
Some benefits of the computer model were that we can see how the disease is spread across a large number of people. In Activity 1, it was only our class size. The simulation also moved quickly. It is also a benefit of the computer model to be able to change the parameter at any time.

2 How can computer models and simulations help doctors make recommendations to the public about how to protect themselves from communicable diseases?

Student responses should demonstrate an understanding of interpreting data. Example response:
Scientists and doctors can use computer models to run simulations of communicable diseases. In the simulations, they can change the parameters to see which factors affect the spread of the disease. The data they collect can help them make decisions about preventing the spread of the disease. They can tell others about what they learned so people know which strategies to take that are most likely to make a difference in keeping them healthy.

Activity 3

# Programming Interactions

Teacher Resources

View Student Course

## EQUIPMENT

The list below is based on a class of 30 students.

| Not Included in Equipment Kit | Device Applications |
|---|---|
| • Grades 3–5 PLTW Launch Logs (1 per student)<br>• Digital devices<br>• Pencils or colored pencils for sketching<br>• Chart paper<br>• Marker | • Inkling<br>• Scratch (For registration information you need prior to signing in, see Preparation.) |

## ESSENTIAL QUESTIONS

EQ

EQ1 How do computer models and simulations help us to make sense of scientific phenomena?
EQ2 In what ways can computer models and simulations be used to predict outcomes?
EQ3 How can a step-by-step process help you design or improve a solution to a problem?

## LEARNING OBJECTIVES

LO

LO4 Apply computational thinking strategies to understand and solve problems.
LO6 Collaborate effectively on a diverse and multidisciplinary team.
LO7 Communicate effectively for specific purposes using the appropriate platform, tool, format, or digital media.
LO8 Practice ethical behavior in all settings.

## KNOWLEDGE AND SKILLS

KS

KS4.3 Compare and refine multiple algorithms for the same task and determine which is the most appropriate. [CSTA 1B-AP-08]
KS4.4 Create programs that use variables to store and modify data. [CSTA 1B-AP-09]
KS4.5 Create programs that include sequences, events, loops, and conditionals. [CSTA 1B-AP-10]
KS4.6 Decompose (break down) problems into smaller, manageable subproblems to facilitate the program development process. [CSTA (1B-AP-11]
KS4.7 Apply a Use-Modify-Create approach to develop programming skills. [CSTA 1B-AP-12]
KS4.8 Use an iterative process to plan the development of a program by including others' perspectives and considering user preferences. [CSTA 1B-AP-13]
KS4.9 Test and debug (identify and fix) a program or algorithm to ensure it runs as intended. [CSTA 1B-AP-15]
KS6.1 Generate ideas as a team.
KS6.2 Value the contributions of each team member.
KS6.3 Demonstrate collaboration through effective communication.
KS6.4 Collaborate with others while pair programming. [CSTA 1B-AP-16]
KS7.1 Document work in an organized notebook.
KS7.2 Explain findings and justify evidence-based conclusions with others.
KS7.3 Present data and information accurately and effectively.
KS8.1 Engage in and maintain positive interactions and relationships with other children and adults.
KS8.2 Engage in positive, safe, and legal behavior while using the internet and technology.

# Preparation

## Professional Development

Before you facilitate Activity 1, access the **Infection: Modeling and Simulation Module-specific PD Resources** to review:

- Computational Thinking
- Building Computational Thinking with Young Children
- Use-Modify-Create Framework

## Part 1. Introduction to Programming

> **Note**: Scratch is a project of the Scratch Foundation, in collaboration with the Lifelong Kindergarten Group at the MIT Media Lab. It is available for free at https://scratch.mit.edu.

1. At least 24 hours before you start this activity, **register** for a Scratch teacher account.
2. After you receive confirmation from Scratch about your teacher account, set up your student accounts. To protect student data and privacy, students save their programs to their Scratch account. These programs are not public.
3. Decide how you want to divide the class into groups. We recommend that students work with a partner. However, if there are not enough devices, students may work in groups of two to four. Consider borrowing devices from other classrooms to complete the activity.

   > **Optional**: If you prefer to have students work in groups of two, but do not have enough devices, consider having half of the class pair program while the other half works in another area of study, then switch tasks.

4. Preview the following **Scratch tutorials**:
   - Getting Started
   - Add a Sprite
   - Animate a Sprite
   - Change Size
5. Become familiar with the Scratch interface. To learn the names of the user interface areas, click the information icons in the image.




Scratch Interface image

## Part 2. Using Conditional Statements

1. Prepare a piece of chart paper titled "Conditional Statements".

| Conditional Statements |
| --- |
| |

2. Complete the **Pong Game tutorial** to become familiar with its content.

## Part 3. Changing Costumes

Create a few sample programs with the given criteria so you can better facilitate this activity with students.

**Time**: 100 Minutes

## Introduction

In this activity, students use *pair programming* to create *programs* in Scratch—a block-based *coding* language. Students view tutorials and write simple programs. They consider the use of *conditional statements* as they create a program to have two sprites interact. This skill will help them develop knowledge and skills to solve the problem.

| | |
|---|---|
| bug | An error in a computer program that causes the program to run incorrectly. |
| code | The instructions for a program. |
| communicable disease | An infectious disease that can spread from one organism to another. |
| computer model | A computer program that is designed to simulate what might happen or what did happen in a situation. |
| conditional statement | A programming element that performs different actions depending on whether a condition is true or false. |
| constraint | A limitation or a restriction. Constraints can include limits on time, materials, and size. |
| criteria | Guidelines or rules used to make a decision about something. |
| debug | To find and fix bugs in a program. |
| driver | The person who controls the device during pair programming. |
| navigator | The person who watches closely, makes suggestions, and asks/answers questions during pair programming. |
| pair programming | When two people work together to create a computer program. |
| parameter | A value that helps to define how a computer model works in a simulation. Parameters can be changed for each simulation to show how the parameter affects the model. |
| program | A set of code given to a computer to accomplish a task. |
| simulation | Using a computer model to see a situation happen, without testing it in real life. |
| variable | Something that changes or can be changed. |

### Possible Student Misconceptions

- **A computer can think for itself**. Computers can only do what you program them to do. Nothing more, nothing less!
- **Computer programmers work alone all the time**. Computer programmers might work alone for a portion of their day. However, they often work together to solve problems. It's important for programmers to communicate and collaborate with others.

## Procedure

### Part 1. Introduction to Programming

1. Direct students to access Activity 3 in the student course and have them read the Introduction.
2. Have students prepare their PLTW Launch Logs for Activity 3.
3. Lead a discussion to review Activities 1 and 2.

- Why do scientists use computer models to simulate the spread of communicable diseases? Direct students to access the flashcard examples to review the vocabulary terms *computer model*, *simulation*, and *communicable disease*.
- How do variables impact the results of a simulation? Direct students to access the flashcard example to review the vocabulary term *variable*.
- How do parameters impact the results of a simulation? Direct students to access the flashcard example to review the vocabulary term *parameter*.

4. Introduce the Pair Programming video. Guide students to work with a partner or small group to view the video to learn about programming in a group.

**Note**: In software development, it is common practice to have two programmers work together at the same workstation. The driver writes the code, while the navigator reviews it. This technique is called Pair Programming.

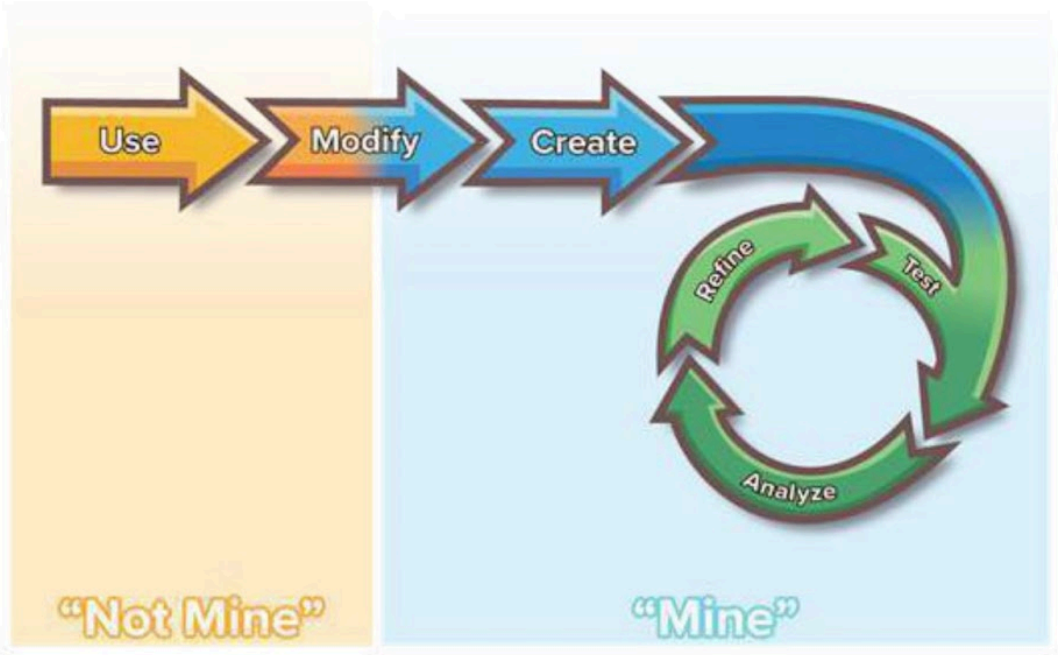
5. Lead a discussion about the video.

   - Why is it important to use pair programming when creating programs? Why do you think this?
     Direct students to access the flashcard examples as you introduce the vocabulary terms *pair programming* and *program*.
   - How are the roles of driver and navigator different?
     Direct students to access the flashcard examples as you introduce the vocabulary terms *driver* and *navigator*.
   - Even though the navigator is not touching the device, why is their role important? Why do you think this?

6. Divide the class into partners or small groups. (See the note in the Preparation section about grouping strategies.) Remind them of the following:
   - Take turns in the roles of driver and navigator. The driver controls the device interface and is the only one who touches or clicks the screen. The navigator watches closely, makes suggestions, and asks/answers questions. Students switch roles during the activity.
   - Follow the guidelines of pair programming:
     - Talk to each other about the work
     - Explain what you are doing or thinking
     - Be respectful of each other
     - Never take the device from the driver

   **Note**: Think-Pair-Share is a strategy where students think individually, discuss ideas with a partner, and then share with the whole class. It increases participation and focus.

7. Give students their usernames and passwords so they can log in to **Scratch**.
8. After students log in, direct them to select **Create**. When students go to the website, the tutorial screen opens. For now, have the students close the tutorial window.
9. Allow 10 minutes for students to explore the Scratch interface. During this time, walk around and view student progress on the basic understanding of the programming environment.
10. At the end of 10 minutes, have groups share what they learned.
11. Introduce the Use-Modify-Create Framework to students. Guide students to view the graphic in the student course.




Use-Modify-Create Framework

12. Explain to students that they will follow these steps to learn more about programming.
    - Use: Interact with tutorials.
    - Modify: Change the sprite, the sprite's action, or backdrop in a program.
    - Create: Write their own programs.

    Use the graphic to help students understand the progression from "Not Mine" to "Mine" as they apply this framework.
13. To provide a guided learning experience, direct students to interact with a few of the short tutorials:
    - Getting Started
    - Add a Sprite

- Animate a Sprite
- Change Size

To view the tutorials, guide students to select **Tutorials** on the menu bar.

**Notes**

- These tutorials are interactive. Each tutorial has a video and slide presentation. Guide students to view the annotated image in the student procedure.
- Encourage students to view the videos first. Then, have them use the slides to drag out code blocks and test the code.
- Remind the students to test their code incrementally (in small pieces) as they build their programs. Waiting until the program is complete to test it, makes it difficult for students to debug issues in their code and may cause frustration.
- Encourage students to remix or modify the program they create in the tutorial. This helps them learn more about programming. They could modify the:
  - Sprite
  - Sprite's action
  - Size of the sprite
  - Costumes
- Students can refer to these tutorials at any time throughout the module.
- If you feel your students need a more guided experience, walk them through how to add a sprite, program the sprite, change its costume, and change its size.
- Allow time for student groups to collaborate so they can teach each other how to add a sprite, program the sprite, change its costume, and change its size.

14 Lead a discussion about the Scratch programming environment.

- After interacting with the tutorials, what are you excited to learn more about?
- How did you modify the programs in the tutorials?
- If you could create any program, what would you create?
- What would you want your sprite to do? How could you use code to program your sprite to do that?

Direct students to access the flashcard examples as you introduce the vocabulary term *code*.

## Part 2. Using Conditional Statements

15 Introduce conditional statements. Direct students to access the flashcard example as you introduce the vocabulary term *conditional statement*.

16 Tell students that conditional statements can be stated in "if...then..." sentences. Provide an example statement for students, and record it on the Conditional Statements chart paper. Example: If we wash our hands, then we help prevent the spread of a communicable disease.

17 Guide students to work with a partner to write examples of "If/Then" statements from their daily lives in their PLTW Launch Logs.

Example If/Then Statements:

- If I eat dinner, then I can have dessert.
- If I have physical education today, then I need to wear my gym shoes.
- If it is snowing, then I can go sledding.
- If I turn in my homework, then I get to go to recess.
- If we work together, then we can solve the problem.

18 Have students share their conditional statement examples. Record their responses on the Conditional Statements chart paper. Address misconceptions that surface as you talk about conditional statements.

19 Have students work with a partner or small group to view the Pong Game tutorial. Guide students to:

- Select **Tutorials** on the menu bar.
- Select Pong Game.

20 As students view the tutorial, remind them to:

- Pause the tutorial to drag out code blocks and test the code.
- Test their code as they build the program. Waiting until the program is complete to test it, makes it difficult for students to debug issues in their code and may cause frustration.
- Modify the program they create in the tutorial. This helps them learn more about programming.

21 Lead a discussion about the tutorial.

- How were conditional statements used in your program?
- How did you program the game to keep score?
- How did you program the sprite to keep moving around the stage?

## Part 3. Changing Costumes

22 Explain to students that they will work with their group to write a program that has two sprites interact.

23 Explain that to create their programs, they have to follow the *criteria* and *constraints*. Use the flashcard examples as you introduce or clarify the vocabulary terms *criteria* and *constraint*.

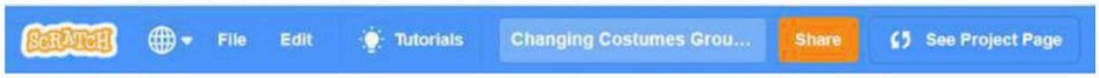
24 Introduce the criteria and constraints of the program.

| Criteria | Constraints |
|---|---|
| The program:<br>• Includes two sprites<br>• Has at least one conditional statement<br>• Has one sprite change costume when touched by the other sprite | • Time<br>• Scratch |

25 Have students work with their partner or group to create a plan for their program. The plan should include:

- The sprites
- The actions of the sprites
- Ideas about how to program the sprites to complete the actions

26 Guide students to give their program a meaningful name. An example is "Changing Costumes Group 1".

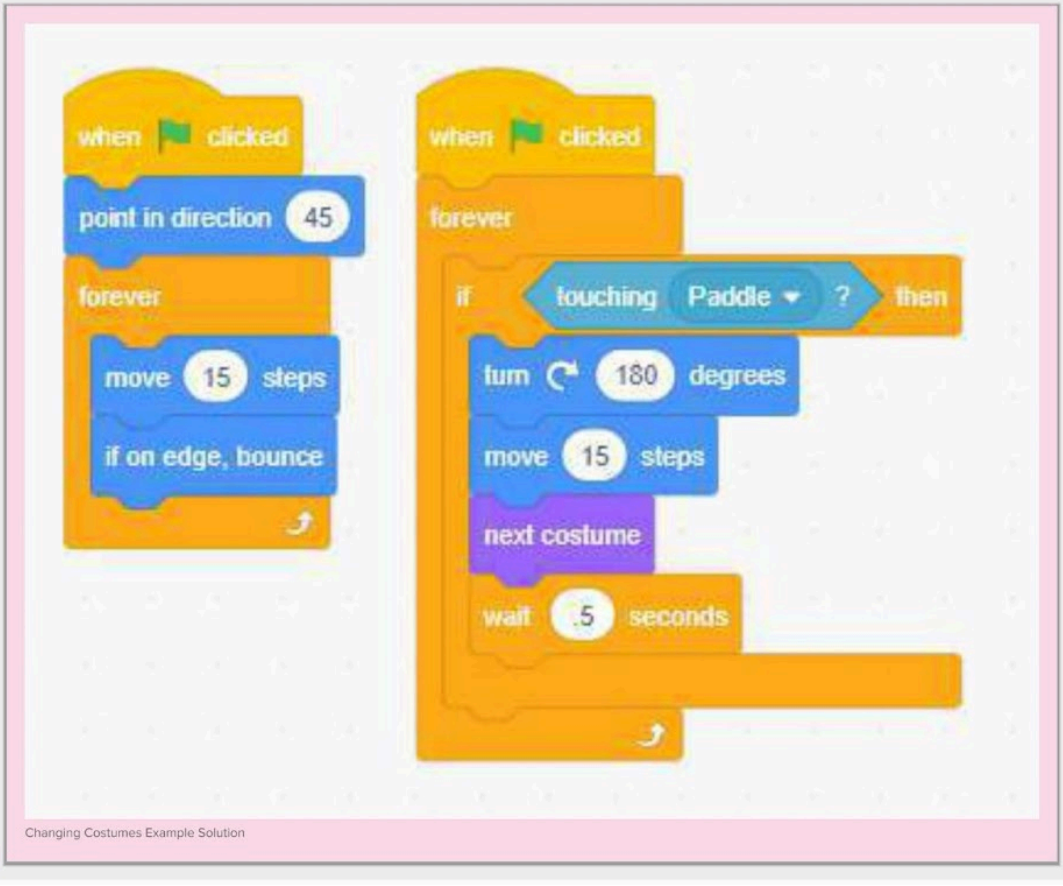



27 Have students type the program name in the box and select **File**. Then select **Save Now**.

28 Allow students about 20 minutes to write a program following the criteria and constraints. Encourage students to use what they learned in the Pong Game and Animate a Sprite tutorials to create their program.

**Note**: Students could create a program in many ways following the criteria and constraints. If they need more support, encourage them to use what they learned in the Pong Game and Animate a Sprite tutorials to create their program.

Below is an example solution using the code from the Pong Game tutorial, with the addition of the **next costume** block.




Changing Costumes Example Solution

29 At the end of this time, have students share their programs with the class. If possible, project the digital device screens with the programs visible so all students can view them. Guide students to:

- Discuss which blocks they chose
- Identify how they used a conditional statement

30 Lead a discussion about the programs.

- What were the similarities in how everyone programmed their sprites? What were the differences?
- What was the biggest challenge you faced? How did you address it?
- As you were testing your program, did it always work as you had intended? Why or why not?
  Direct students to access the flashcard example as you introduce the vocabulary term *bug*.
- What did you do when the program did not work as you had intended?
  Direct students to access the flashcard example as you introduce the vocabulary term *debug*.

31 Guide students to answer the Conclusion Questions. Lead a discussion for students to share their thoughts.

## Conclusion Questions Answer Key

1 What is the importance of conditional statements in computer programming? Use evidence from the activity to explain your thinking.

Student responses should demonstrate an understanding of the conditional statements. Example response:
Conditional statements are important because they help the program determine what to do depending on whether something is true or false. In Part 3, I was able to create code using a conditional statement that told the ball to change costumes if it touched the paddle.

2 What did you learn about programming from viewing other students' programs? What would you like to include in future programs?

Student responses will vary.

3 Why do you think it is good practice to use pair programming?

Student responses should demonstrate an understanding of pair programming. Example response:
It is important to follow the rules of pair programming so everyone in the group gets the chance to control the digital device. One person should not be in the role of the driver the entire time. It is important to take turns. Also, it is important to talk to each other and explain what you are doing or thinking. This helps us learn more about programming.

Project

# Population Simulation

Teacher Resources

View Student Course

## EQUIPMENT

The list below is based on a class of 30 students.

| Not Included in Equipment Kit | Device Applications |
|---|---|
| • Grades 3–5 PLTW Launch Logs (1 per student)<br>• Digital devices<br>• Pencils or colored pencils for sketching | • Inkling<br>• Scratch |

## ESSENTIAL QUESTIONS

EQ

EQ1 How do computer models and simulations help us to make sense of scientific phenomena?
EQ2 In what ways can computer models and simulations be used to predict outcomes?
EQ3 How can a step-by-step process help you design or improve a solution to a problem?

## LEARNING OBJECTIVES

LO

LO1.2 Use scientific reasoning to ask questions, make observations, and investigate ideas to make sense of phenomena and solve problems.
LO2 Research ways that communicable diseases are spread from person to person.
LO3 Use computer models to simulate, calculate, and display information about a system.
LO4 Apply computational thinking strategies to understand and solve problems.
LO5.1 Apply mathematical thinking to solve problems.
LO5.2 Apply numbers and operations to solve problems.
LO6 Collaborate effectively on a diverse and multidisciplinary team.
LO7 Communicate effectively for specific purposes using the appropriate platform, tool, format, or digital media.
LO8 Practice ethical behavior in all settings.

## KNOWLEDGE AND SKILLS

KS

| | |
|---|---|
| KS1.2.2 | Make observations to draw conclusions of phenomena. |
| KS1.2.3 | Analyze data to look for patterns or to test whether data are consistent with an initial prediction. |
| KS1.2.4 | Analyze models as an explanation of phenomena. |
| KS2.3 | Identify how the spread of a communicable disease can be slowed down or prevented. |
| KS3.1 | Identify how computer models are used to simulate real world scenarios. |
| KS3.2 | Use computer models to predict, collect, and observe data. |
| KS3.3 | Create a computer model to simulate the spread of a communicable disease. |
| KS3.4 | Identify the parameters in a simple system. |
| KS3.5 | Explain that changing a parameter while running a simulation uncovers how the parameter affects the model system. |
| KS4.1 | Organize and present collected data visually to highlight relationships and support a claim. [CSTA 1B-DA-06] |
| KS4.2 | Use data to highlight or propose cause-and-effect relationships, predict outcomes, or communicate an idea. [CSTA 1B-DA-07] |
| KS4.3 | Compare and refine multiple algorithms for the same task and determine which is the most appropriate. [CSTA 1B-AP-08] |
| KS4.4 | Create programs that use variables to store and modify data. [CSTA 1B-AP-09] |
| KS4.5 | Create programs that include sequences, events, loops, and conditionals. [CSTA 1B-AP-10] |
| KS4.6 | Decompose (break down) problems into smaller, manageable subproblems to facilitate the program development process. [CSTA (1B-AP-11] |
| KS4.7 | Apply a Use-Modify-Create approach to develop programming skills. [CSTA 1B-AP-12] |
| KS4.8 | Use an iterative process to plan the development of a program by including others' perspectives and considering user preferences. [CSTA 1B-AP-13] |
| KS4.9 | Test and debug (identify and fix) a program or algorithm to ensure it runs as intended. [CSTA 1B-AP-15] |
| KS5.1.1 | Make sense of problems and persevere in solving them. [CCSS.MATH.PRACTICE.MP1] |
| KS5.1.2 | Reason abstractly and quantitatively. [CCSS.MATH.PRACTICE.MP2] |
| KS5.1.3 | Model with mathematics. [CCSS.MATH.PRACTICE.MP4] |
| KS5.1.4 | Use appropriate tools strategically. [CCSS.MATH.PRACTICE.MP5] |
| KS5.1.5 | Look for and express regularity in repeated reasoning. [CCSS.MATH.PRACTICE.MP8] |
| KS5.2.1 | Read, write, and compare decimals. [CCSS.MATH.CONTENT.NBT.A.3] |
| KS5.2.2 | Add and divide decimals to calculate the mean. [CCSS.MATH.CONTENT.OA.A.2 and CCSS.MATH.CONTENT.NBT.B.7] |
| KS6.1 | Generate ideas as a team. |
| KS6.2 | Value the contributions of each team member. |
| KS6.3 | Demonstrate collaboration through effective communication. |
| KS6.4 | Collaborate with others while pair programming. [CSTA 1B-AP-16] |
| KS7.1 | Document work in an organized notebook. |
| KS7.2 | Explain findings and justify evidence-based conclusions with others. |
| KS7.3 | Present data and information accurately and effectively. |
| KS8.1 | Engage in and maintain positive interactions and relationships with other children and adults. |
| KS8.2 | Engage in positive, safe, and legal behavior while using the internet and technology. |

# Preparation

## Part 2. Coding with Clones

1. Decide how you want to divide the class into groups. We recommend that students work with a partner. However, if there are not enough devices, students may work in groups of two to four. Consider borrowing devices from other classrooms to complete the activity.

   > **Optional**: If you prefer to have students work in groups of two, but do not have enough devices, consider having half of the class pair program while the other half works in another area of study.

2. To become familiar with the content, preview the Cloning presentation in the student course. As you work through the presentation, complete the step-by-step directions in Scratch. Review the discussion questions in the Procedure.
3. As your students explore Scratch, they will naturally begin to dive deeper into the programming platform. Support students as they develop a curiosity for adding more to their programs than what is required in the project. In the world of computer programming, learning to be a creative producer, rather than a consumer, is an invaluable concept for students.

## Part 3. Designing a Computer Model

To become familiar with the content, preview the Computer Model presentation in the student course. As you work through the presentation, complete the step-by-step directions in Scratch. Review the discussion questions in the Procedure.

**Time**: 120 Minutes

# Introduction

In this project, students use the knowledge and skills they gained in Activity 3 to build a *computer model*. Using Scratch as a tool, they learn about the cloning feature and consider how a timer *variable* can be used to collect data.

Then students use a population *parameter* to explain how population size affects the rate of change in the *simulation*. Students record data in their PLTW Launch Logs and explain their thinking.

| | |
|---|---|
| computer model | A computer program that is designed to simulate what might happen or what did happen in a situation. |
| conditional statement | A programming element that performs different actions depending on whether a condition is true or false. |
| pair programming | When two people work together to create a computer program. |
| parameter | A value that helps to define how a computer model works in a simulation. Parameters can be changed for each simulation to show how the parameter affects the model. |
| program | A set of code given to a computer to accomplish a task. |
| simulation | Using a computer model to see a situation happen, without testing it in real life. |
| variable | Something that changes or can be changed. |

# Procedure

## Part 1. Programming Review

1. Direct students to access the project in the student course and have them read the Introduction.
2. Have students prepare their PLTW Launch Logs for the project.
3. Lead a discussion to review Activity 3.

   - Why is it important to use pair programming when creating a program? Why do you think this?
     Direct students to access the flashcard examples as you review the vocabulary terms *pair programming* and *program*.
   - Programs do not always work as intended. How did you work with your partner or group to debug your program?
     Direct students to access the flashcard examples as you review the vocabulary terms *bug* and *debug*.

4. Guide students to consider how they can apply what they have learned so far to design their own computer model in the problem.

> **Note**: Remember that student learning is being scaffolded toward the problem. The questions are designed to spur their thinking as they continue to build knowledge and skills. They should not be expected to have a thorough understanding of how the skills will be applied or what they still need to learn to be ready to solve the problem.

- In what ways do you think using conditional statements will help you design a computer model? Why do you think that?
  Direct students to access the flashcard examples to review the vocabulary terms *conditional statement* and *computer model*.

  Example response: Conditional statements tell a sprite which actions to do given different situations. To create a computer model, we need to tell the sprites what to do when certain parameters are used.

- In what ways can having a sprite change costumes help you design a computer model? Why do you think that?

  Example response: In Activity 3 we used a conditional statement to program a sprite to change costume when another sprite touched it. This could be used in the problem, because we will want the sprites to change colors, or costumes, to represent people becoming infected.

- What else do you need to learn to help you create a simulation for different size populations? Direct students to access the flashcard example to review the vocabulary term *simulation* .

  Example response: We need to find a way to simulate large populations, so we can get more accurate results.

## Part 2. Coding with Clones

5. Review how scientists use computer models to predict more reliable results. Computer models run simulations that mimic how communicable diseases are spread. Scientists use them to predict the spread because computer models:
   - Are ethical. They do not infect real people.
   - Can simulate parameters. This lets you see the impact of different prevention strategies on controlling the spread of an illness.
   - Simulate the spread across large groups of people—even the global population!
   - Can run simulations multiple times to get more accurate data.
6. In Scratch, students can change the number of sprites in several ways to represent a large population:
   - Create a sprite to represent each person. This method would take a very long time, especially if you want large populations such as 100 people.
   - Create one sprite, and program it using the cloning feature. With this feature, a sprite can create copies of itself by typing the population value.
7. Have students log in to Scratch. Students need to be able to switch between Scratch and the student course on their device. Demonstrate this for students.
8. Guide students to work with a partner or small group to view the Cloning presentation in the student course and program in Scratch. Students may need guidance to move between the presentation and coding in Scratch. If your classroom has one-to-one devices, consider partners having the presentation on one device and Scratch on the other.
9. Guide students to give their program a meaningful name. An example is "Project Group 1".
10. Have students type the program name in the box and select **File.** Then select **Save Now**.
11. Guide students to talk to their groups about the benefits of using the cloning blocks instead of creating individual sprites.

## Part 3. Designing a Computer Model

12. Guide students to work with a partner or small group to view the Computer Model presentation in the student course and program in Scratch.
13. Remind students to save their program.
14. Now that your students have created a computer model, guide them to consider how to modify it. Examples for modifications include:
    - Motion blocks used
    - Values inside the motion blocks
    - Costumes
    - Names of costumes
    - Number of clones

> **Note**: As students work through this step, assess their understanding and comfort level with working with this computer model. Ask questions to uncover where they may need help. Use tutorials to help as needed.

## Part 4. Collecting Data

15 Explain to students that they will use their computer models to run simulations of a population parameter. They will use the timer variable to collect data for how long it takes for all of the clones to change costumes.

- Direct students to access the flashcard examples to review the vocabulary terms *parameter* and *variable*.
- Remind students of the parameters they tested in Activity 2: No Prevention, Staying Home, and Washing Hands.
- Describe that with this computer model, other parameters could be tested, such as:
  - How fast the sprites move using the values in the Motion blocks
  - Size of the sprites
- Explain that to test a population parameter, they will use the cloning feature in Scratch.
- Describe that while the timer variable in this computer model runs in seconds, scientists use sophisticated ways to allow the timer to represent time passing, such as by days.

16 Guide students to draw the Number of Clones chart in their Launch Log.

| Number of Clones | | | |
|---|---|---|---|
| Trial | 10 | 100 | 250 |
| 1 | ____ seconds | ____ seconds | ____ seconds |
| 2 | ____ seconds | ____ seconds | ____ seconds |
| 3 | ____ seconds | ____ seconds | ____ seconds |
| Mean (Average) | ____ seconds | ____ seconds | ____ seconds |

17 Direct students to make a prediction about the number of clones (10, 100, or 250) that will result in the:

- Least time for all clones to change costumes
- Greatest time for all clones to change costumes

18 Guide students to run three trials of the simulation for each number of clones. They should stop the simulation when each clone has changed costume.

19 Direct students to record their results in their chart.

20 Guide students to calculate the mean for each column.

21 Have students share their data with the class. If possible, project the digital device screens with the programs visible so all students can view them. Guide students to:

- Discuss the data they collected
- Identify how the population parameter affects how quickly the clones change costumes

22 Lead a discussion about the computer models.

- Imagine that changing costumes represents becoming infected by a communicable disease. How does the size of a population impact how quickly the disease spreads?
- What variable did you test in your computer model?

  Time

- What parameter did you test in your computer model?

  Population size

- What are some other parameters you could have tested with this computer model?

  - How fast the sprites move using the values in the Motion blocks
  - Size of the sprites

23 Guide students to answer the Conclusion Questions. Lead a discussion for students to share their thoughts.

## Conclusion Questions Answer Key

1 What advantage is there in being able to create clones when programming a simulation?

Student responses should demonstrate understanding of the cloning features in Scratch. Example response:
It would be difficult to copy a program to a lot of sprites. Sometimes simulations have large populations. If I wanted to run a simulation for 1,000 people, it would take a long time to create 1,000 sprites! Instead, I can program one sprite and copy it as many times as needed by typing the number. I can change the number to see what happens in the simulation to collect data.

2 Imagine the computer model you created was used to simulate the spread of a communicable disease. Why is it important to understand how the number of clones impacted time? Use evidence from your data to explain your thinking.

Student responses should demonstrate an understanding of how the parameters in their computer model impacted time. Example response:
If the computer model we created was to simulate the spread of a communicable disease, we can use the data we collected to see how quickly it will spread across the population. With clones, we can see that with larger gatherings, the disease spreads quicker. Scientists could use these results to determine how to slow down the spread by having people stay home or prevent large gatherings.

Problem

# Simulating Communicable Diseases

Teacher Resources

View Student Course

## EQUIPMENT

The list below is based on a class of 30 students.

| Not Included in Equipment Kit | Device Applications |
|---|---|
| • Grades 3–5 PLTW Launch Logs (1 per student)<br>• Digital devices<br>• Paper<br>• Pencils or colored pencils for sketching | • Inkling<br>• Scratch |

## RESOURCES

R

- Research Resources
- Decision Matrix
- Summative Assessment

## ESSENTIAL QUESTIONS

EQ

EQ1 How do computer models and simulations help us to make sense of scientific phenomena?
EQ2 In what ways can computer models and simulations be used to predict outcomes?
EQ3 How can a step-by-step process help you design or improve a solution to a problem?

## LEARNING OBJECTIVES

LO

LO1.1 Follow a step-by-step method to solve a problem.
LO1.2 Use scientific reasoning to ask questions, make observations, and investigate ideas to make sense of phenomena and solve problems.
LO2 Research ways that communicable diseases are spread from person to person.
LO3 Use computer models to simulate, calculate, and display information about a system.
LO4 Apply computational thinking strategies to understand and solve problems.
LO5.1 Apply mathematical thinking to solve problems.
LO6 Collaborate effectively on a diverse and multidisciplinary team.
LO7 Communicate effectively for specific purposes using the appropriate platform, tool, format, or digital media.
LO8 Practice ethical behavior in all settings.

| KNOWLEDGE AND SKILLS | KS |
|---|---|
| KS1.1.1 | Define a simple design problem reflecting a need or a want. |
| KS1.1.2 | Brainstorm possible solutions to the problem. |
| KS1.1.3 | Make and use a model to test a design, or aspects of a design, and to compare the effectiveness of different design solutions. |
| KS1.1.4 | Evaluate a model solution through observations and/or measurements and consider what revisions to the initial model are needed. |
| KS1.2.1 | Ask and identify questions to gain knowledge or solve problems. |
| KS1.2.2 | Make observations to draw conclusions of phenomena. |
| KS1.2.3 | Analyze data to look for patterns or to test whether data are consistent with an initial prediction. |
| KS1.2.4 | Analyze models as an explanation of phenomena. |
| KS2.1 | Explain that a communicable disease is contagious, which means a person can spread the infection to others. |
| KS2.2 | Explain ways communicable diseases are spread from one person to another. |
| KS2.3 | Identify how the spread of a communicable disease can be slowed down or prevented. |
| KS3.1 | Identify how computer models are used to simulate real world scenarios. |
| KS3.2 | Use computer models to predict, collect, and observe data. |
| KS3.3 | Create a computer model to simulate the spread of a communicable disease. |
| KS3.4 | Identify the parameters in a simple system. |
| KS3.5 | Explain that changing a parameter while running a simulation uncovers how the parameter affects the model system. |
| KS4.1 | Organize and present collected data visually to highlight relationships and support a claim. [CSTA 1B-DA-06] |
| KS4.2 | Use data to highlight or propose cause-and-effect relationships, predict outcomes, or communicate an idea. [CSTA 1B-DA-07] |
| KS4.3 | Compare and refine multiple algorithms for the same task and determine which is the most appropriate. [CSTA 1B-AP-08] |
| KS4.4 | Create programs that use variables to store and modify data. [CSTA 1B-AP-09] |
| KS4.5 | Create programs that include sequences, events, loops, and conditionals. [CSTA 1B-AP-10] |
| KS4.6 | Decompose (break down) problems into smaller, manageable subproblems to facilitate the program development process. [CSTA (1B-AP-11] |
| KS4.7 | Apply a Use-Modify-Create approach to develop programming skills. [CSTA 1B-AP-12] |
| KS4.8 | Use an iterative process to plan the development of a program by including others' perspectives and considering user preferences. [CSTA 1B-AP-13] |
| KS4.9 | Test and debug (identify and fix) a program or algorithm to ensure it runs as intended. [CSTA 1B-AP-15] |
| KS5.1.1 | Make sense of problems and persevere in solving them. [CCSS.MATH.PRACTICE.MP1] |
| KS5.1.2 | Reason abstractly and quantitatively. [CCSS.MATH.PRACTICE.MP2] |
| KS5.1.3 | Model with mathematics. [CCSS.MATH.PRACTICE.MP4] |
| KS5.1.4 | Use appropriate tools strategically. [CCSS.MATH.PRACTICE.MP5] |
| KS5.1.5 | Look for and express regularity in repeated reasoning. [CCSS.MATH.PRACTICE.MP8] |
| KS6.1 | Generate ideas as a team. |
| KS6.2 | Value the contributions of each team member. |
| KS6.3 | Demonstrate collaboration through effective communication. |
| KS6.4 | Collaborate with others while pair programming. [CSTA 1B-AP-16] |
| KS7.1 | Document work in an organized notebook. |
| KS7.2 | Explain findings and justify evidence-based conclusions with others. |
| KS7.3 | Present data and information accurately and effectively. |
| KS8.1 | Engage in and maintain positive interactions and relationships with other children and adults. |
| KS8.2 | Engage in positive, safe, and legal behavior while using the internet and technology. |

# Preparation

## Professional Development

Before you facilitate the problem, access the **Launchpad** to review:

- Thinking Like an Engineer
- Developing Research Skills with Elementary Students

## Problem

1. Become familiar with the procedures for facilitating this problem with your students. In this problem, students design a computer model that simulates the spread of a communicable disease.
2. Create your own computer model based on the criteria and constraints. This helps you to facilitate the problem with students and understand challenges they may face.
3. During the Explore step of the design process, students research communicable disease simulations. Review the **Research Resources** and websites that students can use during the Explore step.
4. During the Evaluate step of the design process, each group will pair with another group to exchange computer models and instructions to review and receive feedback. Plan how you will create and organize review groups.
5. Think of ways for students to present their computer models outside of the classroom. Options include presenting at a local library, doctor's office, or school board meeting. If students are unable to present outside the classroom, invite guests to observe the computer models. Guests can include parents, school board members, and local community leaders.
6. As students work through the design process to develop a solution, use the Summative Rubric to assess their demonstration of learning. A printable version of the rubric is accessible in the Resources section of **Summative Assessment**. Use the rubric as a guide throughout the process of solving the problem.
7. Become familiar with the **Decision Matrix**. The decision matrix is a tool that allows students to rate the designs based on the criteria. If desired, you can print a copy of the decision matrix for each student to complete and glue in their PLTW Launch Log.

**Time**: 180 Minutes

# Introduction

In this problem, students follow the *design process* to research, design, and evaluate a *computer model* that *simulates* the spread of a *communicable disease*. Students present their *computer models* to their classmates and explain how scientists could use their model to prevent or slow down the spread of the disease.

| | |
|---|---|
| constraint | A limitation or a restriction. Constraints include limits on time, materials, and size. |
| criteria | Guidelines or rules used to judge or make a decision about something. |
| design process | A step-by-step way to solve problems. |

# Procedure

1. Review the Introduction Story: *Understanding the Spread* with students. Remind students that their challenge is to design a computer model that simulates the spread of a communicable disease.
2. Direct students to access the problem in the student course and have them read the Introduction.
3. Direct students to access the flashcard example as you introduce the vocabulary term *design process*.
   - Ask students to share examples of how they have used a step-by-step process to complete a task. Examples include:
     - Getting ready for school
     - Brushing their teeth
     - Solving a math problem
     - Making a snack
   - Explain to the students that they are going to use the same steps that engineers use to design new items and improve existing items.
4. Present the Design Process video as an introduction to engineers and the design process.




Design Process video

5. Lead a discussion about what students learned from the Design Process video.

   - Why do engineers use the design process?
   - How do you think the design process helps engineers in their work?
   - Why is it important to ask questions as you work through the design process? Why do you think that?
   - In the video, we learned that it is important to understand the problem before looking for a solution. Have you ever identified a problem and then looked for a solution? Allow students to share their thoughts.

6. For the problem, the PLTW Launch Log has a guided section titled, "Solving the Problem." Guide students to locate and preview this section in their Launch Logs. Students record notes, sketches, and ideas for each step of the design process. Remind students that it is important to include details that provide evidence for their thinking throughout the process.

7. Guide students to follow the design process to design a computer model.

8. The first step in the design process is **Ask**.
   - Have students consider what they learned about the Ask step in the Design Process video. In this step, students ask questions to make sure they have a clear understanding of the problem and the criteria and constraints for their design.
   - Guide a discussion where students ask questions to gather information that will help them define the problem.
   - With support and guidance, the students define the problem, "How can I design a computer model that simulates the spread of a communicable disease?"
   - Explain that when engineers solve problems, they have to follow the *criteria* and *constraints* for the solution. Use the flashcard examples as you review the vocabulary terms *criteria* and *constraint*.
   - Introduce the criteria and constraints of the design.

| Criteria | Constraints |
|---|---|
| • The program:<br>  ▪ Models the spread of a communicable disease across a population<br>  ▪ Includes at least one conditional statement<br>  ▪ Includes at least one variable<br>  ▪ Simulates at least two parameters<br>• The instructions for the computer model include:<br>  ▪ An introduction<br>  ▪ How to run the simulation<br>  ▪ How to collect data<br>  ▪ How to analyze data | • Time<br>• Scratch<br>• Available research |

   - Guide the students in a discussion to consider the problem, criteria, and constraints.

- What information do I have that will help me solve this problem?
- What knowledge or skills do I need to create a solution that will solve the problem?
- In what ways can we use conditional statements to program a computer model?
- In what ways can we use variables to collect data?
- In what ways can we use parameters to collect data?
- What is the need or want that we are trying to fulfill?
- What will make the design solution successful?
- What constraints will impact the solution?

- Guide students to record their responses in the Ask step of their Launch Logs.
- Have students complete the self-reflection at the end of the Ask section in their Launch Logs. Guide students to circle one statement in each row. Assess student understanding and record comments as needed.

> **Note**: At the end of each stage of the design process, students complete a self-reflection. This self-reflection is intended for students to provide honest feedback about their skills during each stage. They are not expected to be "advanced" in all areas all the time. Explain to students that this self-reflection is intended to help them grow as problem-solvers.

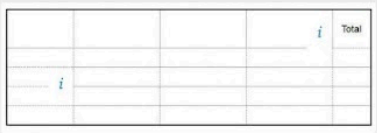
9 The second step in the design process is **Explore**.

- Guide students to research communicable disease simulations to learn more about their features. See **Research Resources** for research options.
- Assist your students to use the simulation examples to observe the:
  - Parameters, such as:
    - Hand washing
    - Social distancing
    - Recovery rate
    - Days to recovery
  - Variables, such as:
    - Number of infected people
    - Time
    - Average daily cases
  - Population sizes
  - Information on how to run the simulation
  - Data that is collected and analyzed, such as:
    - Tables
    - Graphs
- Have students record their research findings in the Explore section of their Launch Logs.
- Guide students to brainstorm several ideas that may solve the problem. Direct students to consider the computer model they explored in Activity 2, and the model they created in the Project, as a guide for what they are creating in the Problem. Students may use the skills and knowledge they gained from the activities and project in this module, as well as information they gathered from their research.
- Direct students to record ideas in the corresponding section of their Launch Logs and use labeled sketches to detail their computer model and instructions.
- Guide students to share their initial ideas with their group. Encourage them to add new ideas by writing or sketching in their Launch Logs.
- Have students complete the self-reflection at the end of the Explore section in their Launch Logs. Assess student understanding and record comments as needed.

10 The third step in the design process is **Model**.

- Introduce a decision matrix as a way to decide on the best design. Using the **Decision Matrix**, students rate each group member's design based on a 0–1 scale for each category. If the design does not meet the criterion in a category, it receives a 0 in that category. If the design does meet the criterion, it receives a 1. The design with the highest total score offers the best solution from the group.

> **Note**: Students may use the decision matrix in their Launch Logs or the copy you provide. If they use the one in their Launch Logs, they need to complete the column and row headers as shown.




- Guide students to use the chosen solution to create their computer model and instructions.
- Remind students to revisit the criteria so their design contains all elements.

- To facilitate creation of the computer models, circle around the room and assess student progress. Ask students to share their ideas and their thinking with you as they work.
- Have students complete the self-reflection at the end of the Model section in their Launch Logs. Assess student understanding and record comments as needed.

11 The fourth step in the design process is **Evaluate**.

- Guide students to work with their group to test their computer model, using the instructions they created in the Model step. Have them consider:
  - Does your program follow the criteria and constraints?
  - Do your instructions follow the criteria and constraints?
- Allow time for groups to make revisions, if necessary.
- Direct students to swap computer models and instructions with another group. Allow time for each group to try each other's model.
- Guide groups to give each other feedback about the strengths and weaknesses of their computer models.
  - Does the computer model meet the criteria?
  - What worked well?
  - What suggestions for improvement can you offer to the creators of the computer model?
- Guide students to reflect on the strengths and weaknesses of their computer model. Have them consider:
  - Did your computer model solve the design problem?
  - Were your instructions thorough enough for others to run the simulation as indicated?
  - What can you do to improve your computer model?
- After students identify the strengths and weaknesses of their computer models, allow time to revise them and make them better.
- Have students complete the self-reflection at the end of the Evaluate section in their Launch Logs. Assess student understanding and record comments as needed.

12 The fifth step in the design process is **Explain**.

- Have students share their computer models and instructions with the class. If possible, project the digital device screens with the programs visible so all students can view them. Guide students to discuss:
  - Which parameters their computer model can simulate
  - How they used variables
  - How to collect and analyze data from the simulation
- After students view all of the computer models, lead a discussion about their features, strengths, and weaknesses.

  - How could your model help others learn about the spread of a communicable disease?
  - What other parameters could you have used in your computer model? How would these parameters improve or change your computer model?
  - What other variables could you have used in your computer model? How would adding these variables change or improve your computer model?
  - If you could improve anything about your computer model, what would you improve? Why would you improve that aspect?
  - Computer models are used for purposes other than simulating the spread of diseases. What ideas do you have about how you could use a computer model to simulate something in the real world?

- Guide students to complete the Explain section of their Launch Logs. Have students provide suggestions for improvement for their computer model and support those with evidence.
- Have students complete the self-reflection at the end of the Explain section in their Launch Logs. Then assess student understanding and record comments as needed.

13 Guide students to answer the Conclusion Questions. Lead a discussion for students to share their thoughts.

14 Direct students to complete the Infection: Modeling and Simulation Check for Understanding. You can access a printable version of this assessment in the Resources section of **Summative Assessment**.

## Conclusion Questions Answer Key

1 What have you learned about how computer models are used?

Student responses will vary.

2 List two changes you would make to improve your design. Why do you think these two changes would improve your computer model?

Student responses will vary.

Introduction to the Module

# Matter: Properties and Reactions

Teacher Resources



**Distance Learning Support**

For information about PLTW's distance learning support and online learning guides, jump to Distance Learning Support in **PLTW Launch Module-specific PD Resources**.

For distance learning support for facilitating this module, jump to **Distance Learning Support: Matter: Properties and Reactions Teacher Guide**.

## PREFACE

**Time**: 10 instructional hours

In this module, students learn about the three states of matter and the properties that make them unique. They use a simulation to observe the particle arrangement of solids, liquids, and gases, and explore what happens when heat is added or taken away. Students deepen their understanding of matter as they explore the law of conservation of mass.

Then they investigate new substances as they examine what happens when substances are mixed together. Students apply this knowledge as they explore mechanical properties and their application to engineering. Students follow testing procedures for different materials at centers to investigate methods of testing compressibility, hardness, softness and firmness, and tensile strength.

After students establish an understanding of matter and its properties, they take a deeper look at mechanical testing. Students use the design process to design a testing procedure that demonstrates whether a material has the required mechanical properties.

## TRANSFERS

T

T1 Evaluate a problem in a new and novel situation.
T2 Apply a step-by-step design process to solve a problem.
T3 Evaluate a material based on its properties.

## ESSENTIAL QUESTIONS

EQ

EQ1 How do the structures and properties of matter help us solve real-world problems?
EQ2 How do mechanical properties impact engineering design?
EQ3 How can a step-by-step process help you design or improve a solution to a problem?

## UNDERSTANDINGS

U

U1 Scientists and engineers use standard practices to explain the world and solve problems.
U2 Matter is anything that has mass and takes up space.
U3 Mathematical thinkers apply complex thinking and reasoning strategies where thinking is intentional and reflected upon.
U4 Professionals function effectively and efficiently on multidisciplinary teams to be successful.
U5 Professionals communicate effectively with a variety of audiences using multiple modalities to be successful.
U6 Professionals conduct themselves so as to maximize benefits for society and minimize harm.

## LEARNING OBJECTIVES

LO

- LO1.1 Follow a step-by-step method to solve a problem.
- LO1.2 Use scientific reasoning to ask questions, make observations, and investigate ideas to make sense of phenomena and solve problems.
- LO2.1 Conduct investigations to develop an understanding of the properties of matter.
- LO2.2 Make observations to describe materials based on their mechanical properties.
- LO3.1 Apply mathematical thinking to solve problems.
- LO3.2 Apply measurement and data to solve problems.
- LO3.3 Apply geometry to solve problems.
- LO4 Collaborate effectively on a diverse and multidisciplinary team.
- LO5 Communicate effectively for specific purposes and settings.
- LO6 Practice ethical behavior in all settings.

## KNOWLEDGE AND SKILLS

KS

- KS1.1.1 Define a simple design problem reflecting a need or a want.
- KS1.1.2 Brainstorm possible solutions to the problem.
- KS1.1.3 Use evidence to compare and explain the effectiveness of different design solutions.
- KS1.1.4 Evaluate a model solution through observations and/or measurements and consider what revisions to the initial model are needed.
- KS1.2.1 Develop a model to describe phenomena.
- KS1.2.2 Ask and identify questions to gain knowledge or solve problems.
- KS1.2.3 Make observations to draw conclusions of phenomena.
- KS1.2.4 Analyze data to look for patterns or to test whether data are consistent with an initial prediction.
- KS1.2.5 Analyze models as an explanation of phenomena.
- KS2.1.1 Identify the three states of matter—solid, liquid, and gas.
- KS2.1.2 Describe that matter is made of particles too small to be seen.
- KS2.1.3 Develop a particle model to describe matter.
- KS2.1.4 Provide evidence that regardless of the type of change that occurs, the total weight of matter is conserved.
- KS2.1.5 Describe how the mixing of two or more substances can result in a new substance.
- KS2.2.1 Describe how mechanical engineers use mechanical properties and testing in the real world.
- KS2.2.2 Test mechanical properties with a variety of materials.
- KS2.2.3 Design a testing procedure that demonstrates whether a material has the required mechanical properties.
- KS3.1.1 Reason abstractly and quantitatively. [CCSS.MATH.PRACTICE.MP2]
- KS3.1.2 Model with mathematics. [CCSS.MATH.PRACTICE.MP4]
- KS3.1.3 Use appropriate tools strategically. [CCSS.MATH.PRACTICE.MP5]
- KS3.1.4 Organize and present collected data visually to highlight relationships and support a claim. [CSTA 1B-DA-06]
- KS3.1.5 Use data to highlight or propose cause-and-effect relationships, predict outcomes, or communicate an idea. [CSTA 1B-DA-07]
- KS3.2.1 Measure and understand volumes. [CCSS.MATH.CONTENT.5.MD.C.3 and CCSS.MATH.MD.C.4]
- KS3.2.2 Relate volume to the operations of multiplication and addition and solve real world and mathematical problems involving volume. [CCSS.MATH.MD.C.5]
- KS3.3.1 Represent real world and mathematical problems by creating a graph.
- KS4.1 Generate ideas as a team.
- KS4.2 Value the contributions of each team member.
- KS4.3 Demonstrate collaboration through effective communication.
- KS5.1 Document work in an organized notebook.
- KS5.2 Explain findings and justify evidence-based conclusions with others.
- KS5.3 Present data and information accurately and effectively.
- KS6.1 Engage in and maintain positive interactions and relationships with other children and adults.

## RESOURCES

R

- Curriculum Framework
- Connections to Standards
- Fifth Grade Connections to Standards
- Family Letter
- Additional Instructional Resources
- Units of Measurement
- Fifth Grade Curriculum Revisions
- Device Specifications
- Application List

# Preparation

## Curriculum Framework and Connections to Standards

Before you facilitate this module, review the Curriculum Framework and Connections to Standards documents.

Standards are the foundation for what is taught in a classroom. They outline what students are expected to learn and be able to do as a result of participating in learning experiences. When planning the implementation of any curriculum, it is essential to identify which standards the curriculum addresses and any standards it does not. This offers greater insight into what the curriculum provides your students and any standards that you may need to address beyond the content provided.

For each PLTW Launch module, teachers are provided a curriculum framework document, which offers a three-stage approach to curriculum planning, assessment, and instruction. The framework document offers a big picture view of the module including the desired results of student learning, assessment opportunities that call for evidence of student learning, and an overview of the scaffolded approach to student learning.

Within the desired results of student learning in the curriculum framework, information is included about module connections to the following standards, when applicable:

- Next Generation Science Standards (NGSS)
- Common Core State Standards (CCSS) in English/Language Arts (ELA) and Mathematics
- Computer Science Teachers Association K–12 Computer Science Standards (CSTA)
- International Society for Technology in Education (ISTE)
- National Association for the Education of Young Children (NAEYC) Early Learning Program Standards
- Head Start Early Learning Outcomes Framework

We understand that your state might not align to these bodies of standards. That is why PLTW Launch is designed for flexible implementation. If your state does not address these standards, spend time comparing your state standards to those identified for the module. Remember that PLTW Launch modules can be implemented at any PreK–5 grade level based on your state standards. Also keep in mind that if you implement a module at a different grade level than indicated, you might need to make modifications to meet the needs of your students.

Exploring this framework resource before you examine the Teacher Guide gives you a high-level understanding of the stages to curriculum planning, assessment, and instruction. You can also determine how the module connects to the required standards for your state. After you have explored the curriculum framework document, you'll be ready to explore the step-by-step instructions in the Teacher Guide.

## Professional Development PD

### Resources

Before you facilitate the Matter: Properties and Reactions module, review the professional development resources.

- Access the **Launchpad** to review:
  - Three Dimensional Learning
  - Claims and Evidence
  - The Teacher as Facilitator
  - PLTW Formative Assessment
  - Using PLTW Launch Logs
  - Uncovering and Addressing Misconceptions
  - The APB Instructional Approach
  - Setting the Stage for APB Learning
  - Thinking Like an Engineer
  - Developing Research Skills with Elementary Students
  - The Design Process Song: Version 1
  - The Design Process Song: Version 2
- Access the **Matter: Properties and Reactions Module-specific PD Resources** to review:
  - Matter: Properties and Reactions APB Overview
  - Matter: Properties and Reactions Module Introduction

### Questioning Skills

As you facilitate APB learning, asking probing questions is essential. Within each activity, project, and problem throughout this Teacher Guide, you will notice sample prompts to ask your class. The prompts guide you to ask thought-provoking questions, as well as to identify conceptions and misconceptions.

As you work with your students, remember that you are not limited to the prompts provided. The best way to determine the types of questions to ask your students comes from observing and interacting with your students as they engage in the module. This provides formative assessment of students' conceptual development and allows you to uncover and address misconceptions.

Building your questioning skills increases your capacity to facilitate powerful student learning. For more information, review the following professional development resources in the **Launchpad**:

- The Art of Questioning

- Building Your Questioning Skills

## Community

As a PLTW Launch Classroom teacher, you are enrolled in discussion groups that allow you to network with other teachers. These discussion groups are in the Community tool in myPLTW. In these groups, you can communicate with other teachers about topics such as general information, modules, and equipment and software. You also have the opportunity to share success stories.

Before you facilitate a module, it is a good idea to review the posts in the groups to gather helpful information from teachers who have previously taught the module. If you have specific questions or comments to make, these discussion groups are a great way to connect with the PLTW Launch network.




Getting Started with myPLTW Community video

## Units of Measurement

To become familiar with the units of measurement and their abbreviations used in PLTW Launch modules, use the Key below. A **Units of Measurement** list is provided for you to print and share with students.

| Key | |
|---|---|
| Unit | Abbreviation |
| centimeter | cm |
| cup | c |
| fluid ounce | fl oz |
| foot | ft |
| gallon | gal |
| gram | g |
| inch | in. |
| liter | L |
| meter | m |
| miles per hour | mph |
| milliliter | mL |
| millimeter | mm |
| ounce | oz |
| pint | pt |
| pound | lb |
| quart | qt |
| tablespoon | tbsp |
| teaspoon | tsp |

## Family and Community Relationships

Family and community relationships are encouraged throughout the module. A **Family Letter** is provided to introduce Project Lead The Way to families, ask for donations to complete specific activities, projects, or problems, and encourage families to support students' learning of concepts at home. PLTW recommends that you send this letter to families before you begin a module, to let them know what their students will be learning in school. A section titled "Dealing with Misconceptions" is also provided in the letter, so families can gain an understanding of the concepts introduced within the module.

FAMILY CONNECTION

Throughout the module, each activity, project, and problem includes a Family Connection section identified by this house icon. These sections provide activities families can do to support what students are learning. Families can use the log-in information provided in the Family Letter to access the course activities.

Establish community relationships throughout the Matter: Properties and Reactions module. To encourage career connections in the classroom, you could invite speakers, such as chemists, mechanical engineers, or civil engineers, to talk about properties of matter.

**Tip**: Prepare visitors for ways to best work with young children, such as:

- Bring items for students to touch
- Use visuals
- Keep dialogue short and simple
- Introduce new terms

## PLTW Launch Logs

As students progress through each module, they use PLTW Launch Logs to record their thinking, ideas, observations, and designs. The PLTW Launch Log is not a traditional workbook nor a collection of worksheets; rather it's designed to be an age-appropriate version of an engineering notebook. In the PLTW Launch Logs, students document their learning as they draw and write their ideas.

As the teacher, you can easily use this record of student ideas for formative assessment by evaluating students' demonstrations of their thinking and conceptual understanding. Allowing students to explain the thinking behind their responses to prompts is an invaluable way to uncover misconceptions and guide students to conceptual understanding. To gain a deeper understanding of the purpose and use of PLTW Launch Logs, access the "Using PLTW Launch

Logs" professional development resource in the **Launchpad**.

## Developing Vocabulary

Vocabulary learning has been found most effective when active engagement with a term goes beyond just knowing the definition. Rather than presented in isolated lessons, vocabulary is introduced within the context of the activities, project, and problem. Viewing the course on a digital device, students have as-needed access to a glossary and interactive flashcards. Each card has an audio component, so students can independently review these words throughout the module.




0:00 / 0:07

## Icon Legend

Throughout the Teacher Guide, the following icons have special meanings.



### Digital Device

The Digital Device icon indicates times when you or your students will use a device for a learning experience.



### Camera

The Camera icon indicates when you or your students will use a camera for a learning experience. There are many camera options. When possible, the best option is for the students to use the camera on their digital device. However, you might need to assign a class photographer to use a digital camera, or you may be the photographer with the camera on your smartphone.



### Centers

The Centers icon indicates when your students will engage in hands-on learning experiences at a variety of centers.




### Professional Development

The Professional Development (PD) icon indicates when a resource is available to provide additional information to you as a teacher. You can find these resources in the PLTW Launch Module-specific PD Resources course.

## Additional Instructional Resources

Project Lead The Way understands the importance of introducing literature, music, and rhyme to students. As such, we created a list of **additional resources** specific to this module. These resources are not included in the equipment kit, and they are not covered in the 10 instructional hours of the module. Incorporating the resources is optional, but they offer ways to provide additional engagement with the concepts explored in this module.

## Curriculum Revisions

The Launch curriculum is continuously updated to provide content and instructional resources that are current and based on best practices. Significant revisions to the curriculum implemented since the prior release of Launch are documented in the **Fifth Grade Curriculum Revisions**.

Introduction Story

# Testing Things Out

Teacher Resources

View Student Course

RESOURCE

R

Introduction Story: Testing Things Out

## Introduction

**Time**: 20 Minutes

To set the stage for learning, guide students to read the Introduction Story: *Testing Things Out*, a fictional story that introduces the problem. You may print the story if needed. This story is divided into four parts: Chapter 1 is read before Activity 1. There are three versions of Chapter 2: 2A, 2B, and 2C, that will be read during the Problem. Students will only read one version of Chapter 2. For more information, refer to the Problem Teacher Resources.

**Sensitively Addressing the Space Shuttle Challenger Incident in Your Class**

Chapter 1: *Mechanical Testing* refers to the 1986 Space Shuttle Challenger disaster. The focus of this chapter is on how mechanical testing impacts engineering design, and it references the materials that caused the disaster. Information about the astronauts onboard the Challenger is not included in the chapter, so that you have the opportunity to sensitively address these details with your class.

For a list of books and resources to introduce these concepts to your students in an age-appropriate way, please refer to the Additional Instructional Resources list found under the Introduction to the Module.

1. Introduce students to the student course and assist them with the log-in process on a digital device. For the rest of the module, students will access the curriculum in the student course.
2. Guide students to access the Introduction Story: *Testing Things Out.* Students can read or listen to the story using audio in small groups. Alternatively, you may read the story aloud as a class.
3. Use the guiding questions within the story to engage students in thinking about ideas and concepts throughout the module. Use this time of discussion to uncover what your students already know about the concepts, what they are curious about, and what misconceptions they have. Consider how this formative assessment of students can guide you as you facilitate the activities, project, and problem in this module. To set the purpose for the learning experiences to come, it's also important to guide students to identify the problem.
4. Throughout the module, students can reread the story to remind themselves of the problem they will be solving.

Activity 1

# States of Matter

Teacher Resources

View Student Course

## EQUIPMENT

This list is based on a class of 30 students.

| Included in Equipment Kit | Not Included in Equipment Kit | Device Applications |
|---|---|---|
| • Ice cube tray<br>• 100 mL beakers (2)<br>• Vanilla scents (2) | • PLTW Launch Logs (1 per student)<br>• Digital devices<br>• Pencils or colored pencils for sketching<br>• Water<br>• Chart paper<br>• Markers | • Inkling<br>• PhET® States of Matter: Basics simulation |

## RESOURCE

R

Grades 3–5 Launch Log

## ESSENTIAL QUESTIONS

EQ

EQ1 How do the structures and properties of matter help us solve real-world problems?
EQ2 How do mechanical properties impact engineering design?
EQ3 How can a step-by-step process help you design or improve a solution to a problem?

## LEARNING OBJECTIVES

LO

LO1.2 Use scientific reasoning to ask questions, make observations, and investigate ideas to make sense of phenomena and solve problems.
LO2.1 Conduct investigations to develop an understanding of the properties of matter.
LO4 Collaborate effectively on a diverse and multidisciplinary team.
LO5 Communicate effectively for specific purposes and settings.
LO6 Practice ethical behavior in all settings.

## KNOWLEDGE AND SKILLS

KS

KS1.2.1 Develop a model to describe phenomena.
KS1.2.5 Analyze models as an explanation of phenomena.
KS2.1.1 Identify the three states of matter—solid, liquid, and gas.
KS2.1.2 Describe that matter is made of particles too small to be seen.
KS2.1.3 Develop a particle model to describe matter.
KS4.3 Demonstrate collaboration through effective communication.
KS5.1 Document work in an organized notebook.
KS5.2 Explain findings and justify evidence-based conclusions with others.
KS6.1 Engage in and maintain positive interactions and relationships with other children and adults.

# Preparation

## Professional Development

Before you facilitate Activity 1, access the **Matter: Properties and Reactions Module-specific PD Resources** to review:

- Building Your Understanding: Solids, Liquids, and Gases
- Building Your Understanding: Computer Models and Simulations

## Part 1. Solids, Liquids, and Gases

**Note**: Students may have learned about states of matter before this module. Before they begin this activity, students should understand:

- Solids have a definite shape and volume, no matter what container they are in.
- Liquids have a definite volume, but take on the shape of the container they are in.
- Gases do not have a definite shape and spread out to fill the container they are in.

If your students need additional support on these scientific concepts, consider using some of the activities in the Materials Science: Properties of Matter module to activate their background knowledge.

1. Before you begin Activity 1:
   - Read Chapter 1 of the **Introduction Story: *Testing Things Out*** with students.
   - Use an ice cube tray to prepare ice. Immediately before you teach the activity, place a few of the ice cubes in a beaker.
   - Fill another beaker with water.
   - Place the vanilla scents on your desk so that the scent has time to fill the room.
2. Prepare a piece of chart paper to represent the three states of matter. This chart will serve as reference to help students visualize the properties of the states, their particle arrangement, and the effect heating and cooling have on each state.

| States of Matter | | | | |
|---|---|---|---|---|
| State | Water | Properties | Particle Arrangement | Temperature |
| **Solid** | | | | |
| **Liquid** | | | | |
| **Gas** | | | | |

3. Review the Solids, Liquids, and Gases presentations in the student course to become familiar with their content. Review the discussion questions in the Procedure.

## Part 2. Particle Simulation

1. Have the States of Matter chart ready to use with students.
2. Test the link to the **PhET States of Matter: Basics** simulation before you present it to students.

> With the *States of Matter: Basics* simulation, students can explore the three states of matter at the particle level. They can heat, cool, and compress the atoms and molecules and watch as they change between solid, liquid, and gas phases.
>
> For more information about how to use the simulation, create a free account at phet.colorado.edu. For each simulation, you will have access to teacher tips and additional language translations.

To begin your review, explore the different features available in the simulation on your own for 5–10 minutes. Then, use the following steps to explore solids and liquids.

- Select the **States** category.
- Select **Water**.
- Select **Solid**. Observe the particle arrangement of water in the solid state.
- Select **Liquid**. Observe the particle arrangement of water in the liquid state.
- Select **Gas**. Observe the particle arrangement of water in the gas state.
- Select **Liquid**.
- Locate the Heat and Cool slider. Slide the tab to **Cool** and hold it there. Watch the temperature decrease on the thermometer. Notice that as the temperature decreases, the particles come back together to form a definite shape. This represents the water changing from a liquid to a solid.
- Slide the tab to **Heat** and hold it there. Watch the temperature increase on the thermometer. Notice that as the temperature increases, the particles lose their structure and collapse to fill the bottom of the container. This represents the water changing from a solid to a liquid.

- Select **Gas**.
- Locate the Heat and Cool slider. Slide the tab to **Cool** and hold it there. Watch the temperature decrease on the thermometer. Notice that as the temperature decreases, the particles come back together to form and collapse to fill the bottom of the container. This represents the water changing from a gas to a liquid.

**Time**: 60 Minutes

## Introduction

In this activity, students activate their prior knowledge of the states of *matter—solid*, *liquid*, and *gas*. They learn that all matter is made of *particles* too small to be seen. Then students explore simulations to examine the particle arrangement of *substances* as heat is added or removed. They develop an understanding that even when particles and gases cannot be seen, they still have *mass* and *volume*.

| | |
|---|---|
| gas | The state in which a substance expands to occupy the volume and shape of its container. The particles are fast moving and can spread apart from each other. |
| liquid | The state in which a substance adapts to the shape of its container, and mostly maintains its volume. The particles are touching but they can move past each other. |
| mass | A measure of the amount of matter in an object. |
| material | The matter from which a thing can be made. |
| matter | Anything that has mass and takes up space. |
| particle | A very small piece of matter. All matter is made of particles too small to be seen. |
| property | A characteristic of a material. |
| solid | The state in which a substance maintains a fixed volume and shape. The particles are packed closely together. |
| substance | Matter that has specific components and properties. |
| volume | The amount of space an object takes up. |

### Possible Student Misconceptions

- **Physical changes are always easily observed**. Physical changes are easy to control or influence, but those changes are not always easily observed. For example, it is easy to put water in an ice tray and place it in the freezer. However, we cannot see the particles coming together to form the solid ice cube.
- **Water must be boiled to change from a liquid to a gas**. When heat is added to a liquid, it evaporates or changes to a gas. Water changes from a liquid to a gas when it reaches boiling temperature; however, it can also evaporate more slowly without being heated.
- **Gases have no mass**. Everything is matter, including gases. All matter has mass and takes up space. Gas fills up the space it is in and takes on the shape of the container or area it is in. Even though we cannot see or feel gases, they still have mass, which can be detected using sensitive scales.
- **Steam and clouds are examples of water in the gas state**. Water vapor is water in the gas state.
  - Steam is the visible transition phase of water from its liquid to its gas state.
  - A cloud is a mass of water droplets and ice crystals suspended in the atmosphere. Clouds form when water condenses in the sky. The condensation lets us see the water vapor.

## Procedure

### Part 1. Solids, Liquids, and Gases

1. Direct students to access Activity 1 in the student course and have them read the Introduction.
2. Students use Launch Logs to keep a record of their work as they progress through the module. Distribute a Grades 3–5 Launch Log to each student. In the notebook, they may take notes as they research, create sketches, and answer conclusion questions.
3. To activate background knowledge, show students the beakers filled with ice cubes and water. Lead a discussion about their similarities and differences.

   - How are the ice cubes and water similar?
   - How are they different?

4. Based on the discussion, introduce or review matter. Guide students to access the flashcard examples to introduce the vocabulary terms *matter* and *mass*.

> **Note**: *Mass* is used within the definition of *matter*, and vice versa. Review these terms together so students have a full understanding.

5. Lead a discussion on matter to address any misconceptions.

- Think about pretzels. What sizes and shapes do pretzels come in?
- Within the different types, is their matter the same or different? Why or why not?
- Are their masses the same or different? Why or why not?

6. Introduce the idea that the ice cube is a solid, one of the states of matter. Tell students that the ice cube, and other types of matter, are all substances. Direct students to access the flashcard examples to introduce the vocabulary terms *solid* and *substance*.
7. Guide students to draw the States of Matter chart in their Launch Logs.
8. Direct students to draw an ice cube for their Solid drawing in their chart.
9. Lead a discussion about solids.

- What are other examples of solids? How do you know they are solids?
- What are some characteristics of solids?
- What do they look like?
- How do they act?

10. Tell students these characteristics are called properties. All matter can be described by their properties. Direct students to access the flashcard examples to introduce the vocabulary terms *property* and *material*.
11. Direct groups to view the Solids presentation in the student course. While they view the presentation, have students take notes in their Launch Logs about the properties of solids.
12. Lead a discussion about the presentation. Record student responses in the Properties column of the States of Matter chart. Direct students to access the flashcard example to introduce the vocabulary term *volume*.

What are some properties of a solid?

13. Introduce the idea that the water in the beaker is a liquid, another state of matter. Direct students to access the flashcard example to introduce the vocabulary term *liquid*.
14. Direct students to draw water for their Liquid drawing in their chart.
15. Lead a discussion on liquids.

- What are other examples of liquids? How do you know they are liquids?
- What are some characteristics of liquids?
- What do they look like?
- How do they act?
- How are liquids different from solids?

16. Direct groups to view the Liquids presentation in the student course. While they view the presentation, have students take notes in their Launch Logs on the properties of liquids.
17. Lead a discussion about the presentation. Record student responses in the Properties column of the States of Matter chart.

What are some properties of a liquid?

18. Ask students to observe the smell in the room. Lead a discussion about the state of the fragrant substance in the room.

- What do you think is causing the scent in the room?
- What does this tell us about how the air in the room has changed?
- Is this scent caused by a solid or liquid? Explain your thinking.

19. Show students the vanilla scents. Tell them the scents are solids, but they have been released into the room into a new state of matter that we cannot see or feel. Direct students to access the flashcard example to introduce the vocabulary term *gas*.
20. Explain to students that water vapor is water in its gas state. Water vapor is transparent, which means it is not visible.
21. Direct students to draw water vapor for their Gas drawing in their chart.

> **Note**: Since water vapor is invisible, students might just write "not visible" or decide to leave the box empty.

22. Lead a discussion about gases.

- What are other examples of gases? How do you know they are gases?
- What are some characteristics of gases?
- What do they look like?
- How do they act?
- How do you know something is a gas?
- How are gases different from liquids? From solids?

23. Direct groups to view the Gases presentation in the student course. Have students take notes in their Launch Logs on the properties of gases while they view the presentation.

> **Note**: As students view the Gases presentation, ensure they understand where to locate in each photo the different gases.
> - Helium: Filling the inside of the balloons, helium gas causes them to float.
> - Oxygen: Located in Earth's atmosphere, oxygen gas is not visible.
> - Water Vapor: A gas that is not visible, water vapor can spread around the room. The steam in the photo is the transition of the water from its liquid to its gas state.
> - Carbon Dioxide: Located inside the bubbles in the soda, carbon dioxide gas pushes the bubbles up to escape.
> - Nitrous Oxide: Compressed inside the container, nitrous oxide gas if released is not visible.

24. Lead a discussion about the presentation. Record student responses in the Properties column of the States of Matter chart.

What are some properties of a gas?

25. Lead a discussion about the properties of solids, liquids, and gases.

- How are the properties of solids, liquids, and gases similar? Use evidence from your chart to explain your thinking.
- How are they different? Use evidence from your chart to explain your thinking.

## Part 2. Particle Simulation

26. Direct students to the **PhET States of Matter: Basics** simulation and give an introduction of the simulation to the class. Students can find the link in the Equipment table or Procedure. Direct students to access the flashcard example to introduce the vocabulary term *particle*.
27. Allow time for students to explore with a partner or small group the features available in the simulation.
28. Guide students to follow the instructions in the student course as they explore solids, liquids, and gases in the simulation. Students should explore the particle arrangement and identify patterns they observe.
29. Guide students to draw the particle arrangement of solids, liquids, and gases in the Particle Arrangement column in their chart as they explore the simulation. Direct students to record observations of temperature in the Temperature column.
30. Lead a discussion about the particles in solids, liquids, and gases.

- What makes solids, liquids, and gases different from one another?

  There are many differences between solids, liquids, and gases, such as:
  - Solids do not change to fit the shape of their container.
  - Solids can be bent, but still have a specific shape.
  - Liquids change their shape based on the container they are in.
  - Liquids flow to fill the lowest part of a container.
  - Gases do not have a specific shape. They fill the container they are in.
  - Gases can expand or be compressed.

- What conclusions can you make about the particles in solids? Liquids? Gases?

  - The particles in solids are packed closely together.
  - The particles in liquids are touching, but they can move past each other.
  - The particles in gases are fast moving and can spread apart from each other.

- How does the behavior of the particles compare to what you know about the properties of solids? Liquids? Gases?

  - Because the particles of solids are packed closely together, solids do not change their shape.
  - Because the particles in liquids are touching but can move past each other, liquids are able to change their shape.
  - Because the particles of gases are fast moving and can spread apart from each other, they do not have a specific shape.

- How does heating and cooling affect the particles? What does this mean about the states of matter?

  Heating and cooling particles allows them to move at different speeds. When heating, the particles move more quickly and bounce off of each other. When cooling, the particles move more slowly and stay closer together. The movement of the particles determines which state of matter the substance is in.

- Do you think a substance can change from a solid to a gas without becoming a liquid first? Why or why not?

  In the vast majority of cases, substances change from a solid to a liquid and then to a gas. As a substance is heated, the particles gain energy allowing them to move faster and spread out. The state of matter of a substance is a result of the spacing and speed of its particles, so as the particles speed up and spread out, the substance changes from a solid, to a liquid, to a gas.

31 Guide students to answer the Conclusion Questions. Lead a discussion for students to share their thoughts.

## Conclusion Questions Answer Key

**Note**: Conclusion Questions offer an opportunity for formative assessment. You may use them as a whole-class discussion or you may have students record ideas in their Launch Logs.

1 Describe the properties of solids, liquids, and gases. Discuss particle arrangement in your answer.

Student responses will vary. Student responses should demonstrate an understanding of properties of matter and particle arrangement. Responses might include:
Solids maintain a fixed volume and shape; their particles are packed closely together. Liquids adapt to the shape of their container, but (mostly) maintain the same volume. The particles in a liquid are close together, but they can move past each other. Gases expand to occupy the volume and shape of their container. The particles in a gas are fast moving and can spread apart from each other.

2 Imagine you leave a cup full of ice out in the sun on a warm day. What will happen to the ice? Use the states of matter to support your answer.

Student responses will vary. Student responses should demonstrate an understanding of the states of matter. Responses might include:
The ice, which is a solid, will melt and turn into a liquid. The liquid will begin to evaporate from the heat and turn into a gas.

## Possible Student Misconceptions

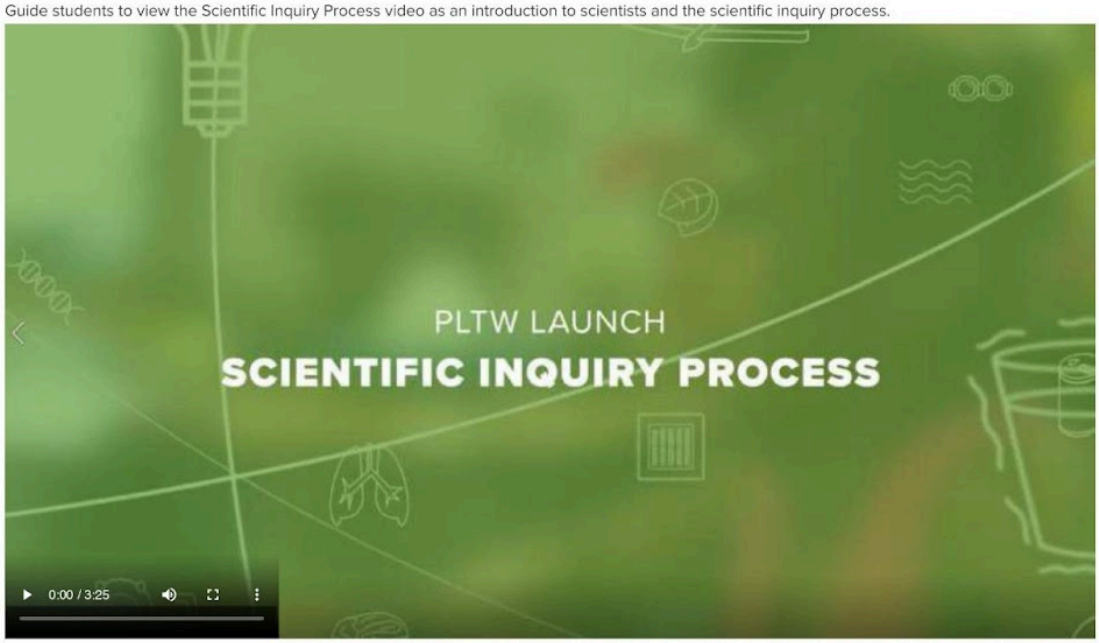
- **Gas particles weigh less than solid particles**. Changes of state are physical changes. Particle shape, size, and mass do not change as a material changes from one state to another. A particle of water vapor and a particle of ice have the same mass.
- **Matter can be destroyed or created**. Matter cannot be made or destroyed; it can only be changed. The amount of matter stays the same even when matter changes form or state.

## Procedure

1. Direct students to access Activity 2 in the student course and have them read the Introduction.
2. Have students prepare their PLTW Launch Logs for Activity 2.
3. Lead a discussion to review Activity 1.

   - What is matter? How can matter be described?
     Direct students to access the flashcard examples to review the vocabulary terms *matter* and *property*.
   - What are some examples of solids? Liquids? Gases?
     Direct students to access the flashcard examples to review the vocabulary terms *solid*, *liquid*, and *gas*.
   - What makes solids, liquids, and gases different from one another?
     Direct students to access the flashcard example to review the vocabulary term *particle*.

4. Introduce the Mixtures investigations. In these investigations, students will investigate what happens to matter when they create mixtures. Through these mixtures, they will observe what happens to mass and volume. Direct students to access the flashcard examples as you introduce the vocabulary term *mixture* and review the vocabulary terms *substance*, *mass*, and *volume*.
5. Ask students what they think scientists do. Discuss that scientists are people who ask questions, make observations, and investigate ideas, to acquire knowledge and/or solve problems. Tell students that they are going to act as scientists as they investigate mixtures.
6. Guide students to view the Scientific Inquiry Process video as an introduction to scientists and the scientific inquiry process.




Scientific Inquiry Process video

7. Lead a discussion about what students learned from the Scientific Inquiry Process video.

   - Why do scientists use the scientific inquiry process?
     Direct students to access the flashcard example as you review the vocabulary term *scientific inquiry process*.
   - How do you think the scientific inquiry process helps scientists in their work?
   - Why is it important to ask questions as you work through the scientific inquiry process? Why do you think that?
   - What makes a question a testable question?

Activity 2

# Conservation: It's the Law!

Teacher Resources

View Student Course

## EQUIPMENT

The list below is based on a class of 30 students.

| Included in the Equipment Kit | Not Included in Equipment Kit | Device Application |
|---|---|---|
| • 50 mL graduated cylinders (16)<br>• 100 mL beakers (10)<br>• Stir sticks (10)<br>• Tablespoons (8)<br>• Digital scales (4)<br>• Disposable transfer pipettes (30)<br>• Sponges (9)<br>• Test tube brushes (10)<br>• Safety glasses (31)<br>• Coarse kosher salt | • PLTW Launch Logs (1 per student)<br>• Digital devices<br>• Pencils or colored pencils for sketching<br>• Pure cane granulated sugar (1 lb)<br>• Iodized salt (26 oz)<br>• Water<br>• Rubbing alcohol (32 fl oz)<br>• All-purpose flour (5 lb)<br>• Liquid dish soap (1 bottle)<br>• Chart paper<br>• Markers | • Inkling<br>• ShowMe Interactive Whiteboard |

## RESOURCE

R

Mixtures worksheet

## ESSENTIAL QUESTIONS

EQ

EQ1 How do the structures and properties of matter help us solve real-world problems?
EQ2 How do mechanical properties impact engineering design?
EQ3 How can a step-by-step process help you design or improve a solution to a problem?

## LEARNING OBJECTIVES

LO

LO1.2 Use scientific reasoning to ask questions, make observations, and investigate ideas to make sense of phenomena and solve problems.
LO2.1 Conduct investigations to develop an understanding of the properties of matter.
LO3.1 Apply mathematical thinking to solve problems.
LO3.2 Apply measurement and data to solve problems.
LO3.3 Apply geometry to solve problems.
LO4 Collaborate effectively on a diverse and multidisciplinary team.
LO5 Communicate effectively for specific purposes and settings.
LO6 Practice ethical behavior in all settings.

## KNOWLEDGE AND SKILLS

KS

| | |
|---|---|
| KS1.2.1 | Develop a model to describe phenomena. |
| KS1.2.2 | Ask and identify questions to gain knowledge or solve problems. |
| KS1.2.3 | Make observations to draw conclusions of phenomena. |
| KS1.2.4 | Analyze data to look for patterns or to test whether data are consistent with an initial prediction. |
| KS2.1.4 | Provide evidence that regardless of the type of change that occurs, the total weight of matter is conserved. |
| KS3.1.1 | Reason abstractly and quantitatively.[CCSS.MATH.PRACTICE.MP2] |
| KS3.1.2 | Model with mathematics. [CCSS.MATH.PRACTICE.MP4] |
| KS3.1.3 | Use appropriate tools strategically. [CCSS.MATH.PRACTICE.MP5] |
| KS3.1.4 | Organize and present collected data visually to highlight relationships and support a claim. [CSTA 1B-DA-06] |
| KS3.1.5 | Use data to highlight or propose cause-and-effect relationships, predict outcomes, or communicate an idea. [CSTA 1B-DA-07] |
| KS3.2.1 | Measure and understand volumes. [CCSS.MATH.CONTENT.5.MD.C.3 and CCSS.MATH.MD.C.4] |
| KS3.2.2 | Relate volume to the operations of multiplication and addition and solve real world and mathematical problems involving volume. [CCSS.MATH.MD.C.5] |
| KS3.3.1 | Represent real world and mathematical problems by creating a graph. |
| KS4.1 | Generate ideas as a team. |
| KS4.2 | Value the contributions of each team member. |
| KS4.3 | Demonstrate collaboration through effective communication. |
| KS5.1 | Document work in an organized notebook. |
| KS5.2 | Explain findings and justify evidence-based conclusions with others. |
| KS5.3 | Present data and information accurately and effectively. |
| KS6.1 | Engage in and maintain positive interactions and relationships with other children and adults. |

# Preparation

## Professional Development

Before you facilitate Activity 2, access the **Matter: Properties and Reactions Module-specific PD Resources** to review:

- Building Your Understanding: Substances
- Using a Pipette

## Activity 2

1. In this activity, students use the Scientific Inquiry Process. This process is similar to the design process, but there are distinct differences. The Scientific Inquiry Process:
   - Is brought into PLTW Launch modules to provide exposure and experience for students to think and work scientifically.
   - Is included in the modules whenever students need to collect data and answer testable questions.
   - Helps students learn how to approach a testable question and set up an experiment to collect the necessary data.

   > **Testable Questions**
   >
   > In the Ask step of the Scientific Inquiry Process, students brainstorm testable questions about a topic. A testable question is one that can be answered by designing and conducting an experiment or investigation. It needs to be specific enough where you only test one variable at a time to draw conclusions. The answers to a testable question can be observed and measured. Examples of testable questions include:
   > - What happens to mass when two substances are mixed together?
   > - What happens when you mix red, blue, and green colored light in different combinations?
   > - Do plants need sunlight to grow?
   > - What affects the brightness of a star in our night sky?

2. Before you begin Activity 2, gather items for the investigations. Use the Family Letter in the Introduction to the Module to ask families for donations. Items you need to request can include iodized salt (26 oz), all-purpose flour (5 lb), pure cane granulated sugar (1 lb), rubbing alcohol (32 fl oz), and liquid dish soap (1 bottle). Each small group needs:
   - **Investigation 1**
     - Pure cane granulated sugar
     - Iodized salt
   - **Investigation 2**
     - Coarse kosher salt
     - All-purpose flour

     > **Note**: If you have students with wheat allergies or sensitivities, consider using an alternative to all-purpose flour, such as cornstarch.

   - **Investigation 3**
     - Iodized salt
     - Water
   - Safety glasses (1 per student)
   - 50 mL graduated cylinders (2)
   - 100 mL beaker
   - Stir stick
   - Disposable transfer pipette
   - Tablespoon
   - Digital scale

     > **Note**: There are four digital scales included in the equipment kit, so two groups may need to share each scale.

   You may wish to have a designated supply table to place the materials, hand out materials to each group, or have a designated table for each investigation for students to rotate through.
3. To avoid contamination and incorrect results, students need to wash and dry their tools between investigations. Depending on classroom size and setup, have a sink available with:
   - Test tube brushes (10)
   - Sponges (9)
   - Liquid dish soap (1 bottle)
4. In this activity, you will model how to mix water and rubbing alcohol together. Review the steps in the procedure to become familiar with the setup. Gather your materials at a table where students can see:
   - Safety glasses (1 pair per student)
   - 50 mL graduated cylinders (2)
   - 100 mL beaker
   - Water (50 mL)

- Rubbing alcohol (50 mL)
- Stir stick
- Digital scale
- Test tube brush
- Sponge
- Liquid dish soap
- Mixtures chart

5. Become familiar with how to use the digital scale. Review the Procedure to see how students will use this to measure the mass of substances.
6. Prepare a piece of chart paper titled "Mixtures". Another option is to create the chart using the ShowMe Interactive Whiteboard app and project the chart for students to view.

| Mixtures | | | | |
|---|---|---|---|---|
| Investigation | Substance A | Substance B | Prediction of Mixture | Mixture |
| Demonstration | Water<br>Mass: ___g<br>Volume: ___mL | Rubbing alcohol<br>Mass: ___g<br>Volume: ___mL | Mass: ___g<br>Volume: __mL | Mass: ___g<br>Volume: __ml |
| 1 | Pure cane sugar<br>Mass: ___g<br>Volume: ___mL | Iodized salt<br>Mass: ___g<br>Volume: ___mL | Mass: ___g<br>Volume: __mL | Mass: ___g<br>Volume: __ml |
| 2 | Coarse kosher salt<br>Mass: ___g<br>Volume: ___mL | All-purpose flour<br>Mass: ___g<br>Volume: ___mL | Mass: ___g<br>Volume: _mL | Mass: ___g<br>Volume: __ml |
| 3 | Iodized salt<br>Mass: ___g<br>Volume: ___mL | Water<br>Mass: ___g<br>Volume: ___mL | Mass: ___g<br>Volume: __mL | Mass: ___g<br>Volume: __ml |

7. Find the Mixtures worksheet in Resources. Print one Mixtures worksheet for each student. Preview the worksheet to become familiar with the instructions and data chart students will use.

**Time**: 90 Minutes

## Introduction

In this activity, students conduct a series of investigations to gain knowledge about *conservation of mass*. In small groups, students use the *scientific inquiry process* as they mix various *substances* and collect data. Through these investigations, students learn that regardless of the type of change that occurs when mixing substances—chemical or physical—the total *mass* of *matter* is conserved.

| | |
|---|---|
| conservation of mass | The principle that matter can neither be made nor destroyed; rather, it can only be transformed or transferred from one form to another. |
| evidence | Information that explains or supports a claim. |
| gas | The state in which a substance expands to occupy the volume and shape of its container. Gas particles are fast moving and can spread apart from each other. |
| liquid | The state in which a substance adapts to the shape of its container and mostly maintains its volume. The particles touch, but they can move past each other. |
| mass | A measure of the amount of matter in an object. |
| matter | Anything that has mass and takes up space. |
| mixture | A substance that contains two or more substances which are not chemically combined. |
| property | A characteristic of a material. |
| scientific inquiry process | A process that scientists use to explore observations and answer questions. |
| solid | The state in which a substance maintains a fixed volume and shape. The particles are packed closely together. |
| substance | Matter that has specific components and properties. |
| volume | The amount of space an object takes up. |

8. **Ask**: Guide students to ask questions so they can set up experiments to test and observe what happens.
   - Ask students to share questions they have about the mass and volume of mixtures. Discuss which of their questions are testable.
   - Present the testable question for this investigation: What happens to mass when two substances are mixed together?
   - Direct students to record the testable question in their Launch Logs.
9. Hand out a Mixtures worksheet to each student.
10. Direct students to go to your prepared table for the demonstration.
11. Model how to create a mixture by mixing water and rubbing alcohol.
    - Model how students will wear safety glasses throughout these investigations by putting on your safety glasses. Direct students to wear their safety glasses as you conduct this demonstration.
    - Label the two materials, water and rubbing alcohol, on your Mixtures chart.
    - Set the digital scale on a table for students to see. Change the unit of measurement on the scale so it will measure in grams (g).
    - Place an empty graduated cylinder on the digital scale. Tare (zero-out) the mass on the scale.

> **Note**: If you would like to incorporate additional mathematical practices with your students, direct them to use addition and subtraction to measure mass instead of using the tare feature on the digital scale.
>
> Explain how to measure the mass of the cylinder, then the mass of the cylinder plus the water. Direct students to subtract the mass of the cylinder from the combined mass to obtain the mass of the water itself.
>
> Alternatively, you may record the masses of the cylinders and beakers ahead of time and have these standard measurements posted for students to use subtraction to determine the masses of the substances.

    - Pour 50 mL of water into the graduated cylinder. Record the mass and volume of the water on your Mixtures chart. Guide students to record this on their Mixtures worksheet.
    - Remove the graduated cylinder with water from the scale and tare the mass on the scale.
    - Repeat the process with a new graduated cylinder and 50 mL of rubbing alcohol.
    - **Predict**: Using the mass and volume of the original substances, guide students to predict what the mass and volume of the mixture will be when the two substances are combined. Direct students to talk to someone near them about what they think the new mass and volume will be for the mixture, and record it on their Mixtures worksheet.
    - **Investigate**: Place a beaker on the scale and tare the mass. Pour the rubbing alcohol and water into the beaker. Use a stir stick to mix the two substances.
    - **Observe**: Record the mass and volume of the mixture on your Mixtures chart. Guide students to record this on their Mixtures worksheet.

> The volume of the mixture should be 5 milliliters less than the total volume of both substances separately (about 95 milliliters). This is unique to rubbing alcohol and water. This is because the particles in the rubbing alcohol are able to slip between the water particles. Therefore, volume decreases because the mixture becomes compacted.
>
> The mass should be conserved (equal to adding the two individual masses together).

    - **Explain**: Lead a discussion about the demonstration.

> - What observations did you make when the two substances were combined?
> - What did you notice about the volume of the mixture? The mass?
> - Was your prediction correct? Why or why not?

    - After you are finished, show students how to carefully wash the beaker, graduated cylinders, and stir stick.
12. With a partner or small group, direct students to make a claim about what happens to mass when two substances are mixed together. Direct students to record this claim in their Launch Logs.
13. Direct students to access the flashcard example as you introduce the vocabulary term *evidence*.

**Note**: When you lead a discussion, it is valuable to begin to use the terms **claims** and **evidence** with students.

A **claim** is a statement about something that answers a question. **Evidence** includes facts or observations that support the claim. When students are asked a question, guide them to make a **claim** followed by **evidence**.

- Claim statement: "I think (or know) that..."
- Evidence statement: "I think (or know) this because I observed (or have done)..."

If a student makes a statement but does not support their claim with evidence, use the following questions to encourage the development of an evidence statement.

- Why do you think that?
- What have you seen or done that makes you think that?
- What evidence do you have that supports your claim?
- Is there anything that made you think that?

Students' evidence may be based on their experiences, observations, or ideas they have learned. During discussions, student misconceptions may arise. Be sure to address misconceptions at this time.

14 **Predict, Investigate, Observe, and Explain**: Explain that students will test their claim by carrying out three additional investigations, using the same process you modeled for them. They will use the data they collect as evidence to support or amend their claim.

- For each investigation, students are able to choose how much of each substance they want to use before mixing. Show students the different measuring tools available:
  - 50 mL graduated cylinders
  - 100 mL beakers
  - Disposable transfer pipettes
  - Tablespoons
- Predict: Students record their predictions about what the mass and volume of each mixture will be on their Mixtures worksheet.
- Investigate
  - **Investigation 1**: Students mix pure cane granulated sugar and iodized salt.
  - **Investigation 2**: Students mix coarse kosher salt and all-purpose flour.
  - **Investigation 3**: Students mix iodized salt and water.
- Observe: Students record the mass and volume of the mixture on their Mixtures worksheet.
- Explain: Students discuss their findings in their small groups. They consider:
  - What observations did you make when the two substances were combined?
  - What did you notice about the volume of the mixture? The mass?
  - Was your prediction correct? Why or why not?

15 As students complete the investigations, circle around the room and assess student progress. Ask students to share their ideas and thinking with you as they work. As you uncover misconceptions, work with students to use the investigations to build accurate conceptual understanding.

**Note**: Students may record small changes in mass. Such differences may be caused by a slight lack of precision in the scale readout or by errors in weighing methods. However, overall results should suggest that mass is conserved in these processes.

16 Remind students to clean their tools between each investigation.

17 Direct students to return to the claim they made before conducting their investigations. Lead a discussion about their claim and evidence.

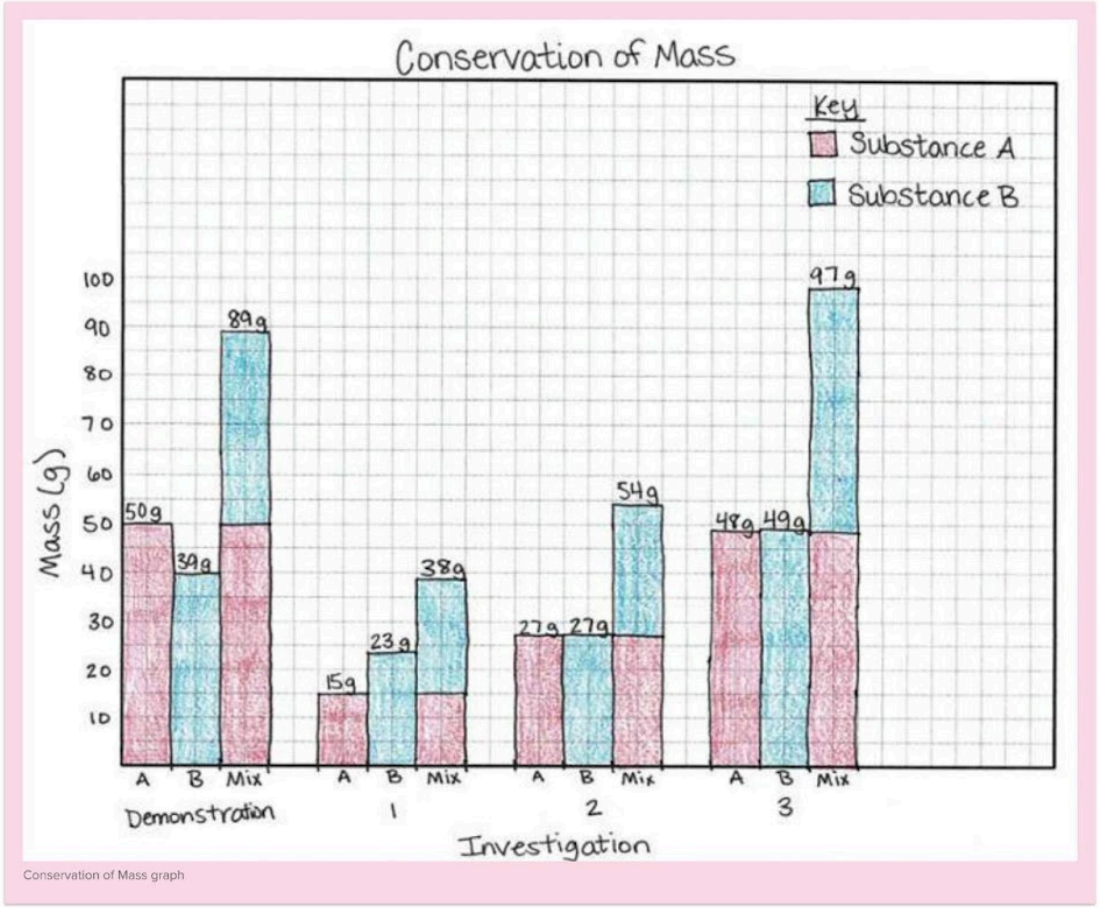
- Was your claim correct? Why or why not? Use evidence to support your thinking.
- If not, how would you change your claim?

18 Guide students to use evidence from the investigations to write a new claim on their Mixtures worksheet.

19 Tell students that the evidence they collected supports a law called conservation of mass. Direct students to access the flashcard example to introduce the vocabulary term *conservation of mass*.

20 Model how to create a bar graph with the data from the investigations. Use a piece of grid chart paper or the ShowMe Interactive Whiteboard app to create the graph. Guide students to create a graph in their Launch Logs while you model.

- Write "Conservation of Mass" as the title.
- Draw x- and y-axes on the grid.
- Label the y-axis "Mass (g)".
- Label the x-axis "Investigation".
- Create a color key for Substance A and Substance B.
- For the demonstration, graph the mass of Substance A, Substance B, and the Mixture.




Conservation of Mass graph

21 Direct students to add the data from the three investigations to their graphs.

22 Lead a discussion about conservation of mass.

- What do you notice about the bars on the graph? What does this tell us about the mass of the substances? Of the mixtures?
- What does this tell us about matter? Consider the mixture of iodized salt and water. Did the salt disappear? How do you know?

> Matter is not created or taken away. When mixing salt and water, the mass was conserved. If we viewed the mixture under a microscope, the particles of both salt and water would be visible.

23 Guide students to answer the Conclusion Questions. Lead a discussion for students to share their thoughts.

## Conclusion Questions Answer Key

1 Review the particle arrangement of a liquid in your Launch Log from Activity 1. How can the particle arrangement provide evidence to support the law of conservation when two substances are mixed?

> Student responses should demonstrate an understanding of particles. Responses might include:
> The law of conservation states matter cannot be made or destroyed; it can only be changed. The amount of matter stays the same even when matter changes form or state. We can provide evidence to support the law of conservation when two substances are mixed by measuring the mass of each substance individually, then mixing the two substances together and measuring the mass again. This will provide evidence that even when two substances are mixed, the mixture will still have the same mass.

2 The weather is nice and warm outside. You decide to make some lemonade to drink. You mix 35 grams of water with 15 grams of a lemonade powder mix. What would be the total mass of the lemonade? Use evidence from the investigation to explain your thinking.

Student responses should demonstrate an understanding of the conservation of mass. Responses might include:
Conservation of mass states that matter cannot be made or taken away. Therefore the mass of the lemonade would be 50 g, because 35 g + 15 g = 50 g.

Activity 3

# Mixing Matter

Teacher Resources

View Student Course

## EQUIPMENT

The list below is based on a class of 30 students.

| Included in Equipment Kit | Not Included in Equipment Kit | Device Applications |
|---|---|---|
| • 50 mL graduated cylinders (16)<br>• 100 mL beakers (10)<br>• Disposable transfer pipettes (30)<br>• Tablespoons (8)<br>• Stir sticks (10)<br>• Safety glasses (31)<br>• Sponges (9)<br>• Test tube brushes (10) | • PLTW Launch Logs (1 per student)<br>• Digital devices<br>• Pencils or colored pencils for sketching<br>• Paper clips (8)<br>• Cooking oil (16 fl oz)<br>• Water<br>• Sand<br>• Iodized salt (26 oz)<br>• Baking soda (1 lb)<br>• Distilled white vinegar (32 oz)<br>• Liquid dish soap (1 bottle)<br>• Chart paper<br>• Markers | • Inkling<br>• Stopwatch<br>• ShowMe Interactive Whiteboard |

## RESOURCE

R

New Substances worksheet

## ESSENTIAL QUESTIONS

EQ

EQ1 How do the structures and properties of matter help us solve real-world problems?
EQ2 How do mechanical properties impact engineering design?
EQ3 How can a step-by-step process help you design or improve a solution to a problem?

## LEARNING OBJECTIVES

LO

LO1.2 Use scientific reasoning to ask questions, make observations, and investigate ideas to acquire knowledge and solve problems.
LO2.1 Conduct investigations to develop an understanding of the properties of matter.
LO3.1 Apply mathematical thinking to solve problems.
LO3.2 Apply measurement and data to solve problems.
LO4 Collaborate effectively on a diverse and multidisciplinary team.
LO5 Communicate effectively for specific purposes and settings.
LO6 Practice ethical behavior in all settings.

## KNOWLEDGE AND SKILLS

KS

| | |
|---|---|
| KS1.2.2 | Ask and identify questions to gain knowledge or solve problems. |
| KS1.2.3 | Make observations to draw conclusions of phenomena. |
| KS1.2.4 | Analyze data to look for patterns or to test whether data are consistent with an initial prediction. |
| KS1.2.5 | Analyze models as an explanation of phenomena. |
| KS2.1.5 | Describe how the mixing of two or more substances can result in a new substance. |
| KS3.1.2 | Model with mathematics. [CCSS.MATH.PRACTICE.MP4] |
| KS3.1.3 | Use appropriate tools strategically. [CCSS.MATH.PRACTICE.MP5] |
| KS3.1.4 | Organize and present collected data visually to highlight relationships and support a claim. [CSTA 1B-DA-06] |
| KS3.1.5 | Use data to highlight or propose cause-and-effect relationships, predict outcomes, or communicate an idea. [CSTA 1B-DA-07] |
| KS3.2.1 | Measure and understand volumes. [CCSS.MATH.CONTENT.5.MD.C.3 and CCSS.MATH.MD.C.4] |
| KS3.2.2 | Relate volume to the operations of multiplication and addition and solve real world and mathematical problems involving volume. [CCSS.MATH.MD.C.5] |
| KS4.1 | Generate ideas as a team. |
| KS4.2 | Value the contributions of each team member. |
| KS4.3 | Demonstrate collaboration through effective communication. |
| KS5.1 | Document work in an organized notebook. |
| KS5.2 | Explain findings and justify evidence-based conclusions with others. |
| KS5.3 | Present data and information accurately and effectively. |
| KS6.1 | Engage in and maintain positive interactions and relationships with other children and adults. |

## Preparation

### Part 1. Properties

1. Have pencils and eight paper clips ready for students to use.
2. Prepare a piece of chart paper titled "Properties of Matter". Another option is to create the chart using the ShowMe Interactive Whiteboard app and project the chart for students to view.

| Physical Properties of Matter |
| --- |
| |

### Part 2. New Substances

1. To become familiar with the content students will explore, review the Muffin video in the student course.

> This video demonstrates that when a new substance is formed:
> - The properties change.
> - The substance cannot be separated and returned to the original substances that were mixed together.

2. Review the Procedure to facilitate the scientific inquiry process with students.
3. If needed, review the Scientific Inquiry Process video found in Activity 2.
4. Before you begin Part 2, gather items needed for the investigations. Use the Family Letter in the Introduction to the Module to ask families for donations. Items you need to request can include cooking oil (16 fl oz), sand, iodized salt (26 oz), baking soda (8 oz), distilled white vinegar (32 oz), and liquid dish soap (1 bottle). Each small group needs:
   - **Investigation 1**
     - 50 mL graduated cylinders (2)
     - 100 mL beaker
     - Disposable transfer pipette
     - Stir stick
     - Cooking oil (10 mL)
     - Water (80 mL)
     - Safety glasses (1 pair per student)
   - **Investigation 2**
     - 50 mL graduated cylinder
     - 100 mL beaker
     - Tablespoon
     - Stir stick
     - Sand (1 tbsp)
     - Water (80 mL)
     - Safety glasses (1 pair per student)
   - **Investigation 3**
     - 50 mL graduated cylinder
     - 100 mL beaker
     - Tablespoon
     - Stir stick
     - Iodized salt (1 tbsp)
     - Water (80 mL)
     - Safety glasses (1 pair per student)
   - **Investigation 4**
     - 50 mL graduated cylinder
     - 100 mL beaker
     - Tablespoon
     - Baking soda (1 tbsp)
     - Distilled white vinegar (50 mL)
     - Safety glasses (1 pair per student)

   You may wish to: have a designated supply table to place the materials, pass out materials to each group, or have a designated table for each investigation for students to rotate through.
5. Find the New Substances worksheet in Resources. Print one New Substances worksheet for each student. Preview the worksheet to become familiar with the instructions and data chart students will use.
6. Before you begin Part 3, review the Investigation Guides in the student course to become familiar with the content students will experience. Follow the directions for each investigation so that you are familiar with what will happen with each mixture.

- **Investigation 1**: Cooking oil and water
- **Investigation 2**: Sand and water
- **Investigation 3**: Iodized salt and water
- **Investigation 4**: Baking soda and distilled white vinegar

> The baking soda and distilled white vinegar mixture may require additional guidance, because this combination produces gas (carbon dioxide). This results in an eruption of bubbles and foam. You may wish to: create a clear space for students to test this mixture, conduct this investigation outside, or lay down a plastic tarp for easy cleanup.

7. Between investigations, students need to wash and dry their tools to avoid contamination and incorrect results. Depending on classroom size and setup, have a sink available with:
   - Test tube brushes
   - Sponges
   - Liquid dish soap

**Time**: 180 Minutes

## Introduction

In this activity, students use the *scientific inquiry process* as they explore mixing different substances. Through this process, students predict whether or not new substances will be created when two substances are mixed. To test their claims, students observe the properties of the substances before and after mixing and find evidence to support their claim.

| | |
|---|---|
| chemical reaction | A process in which one or more substances undergo a change to become a different substance altogether. |
| conservation of mass | The principle that matter can neither be made nor destroyed; rather, it can only be transformed or transferred from one form to another. |
| gas | The state in which a substance expands to occupy the volume and shape of its container. The particles are fast moving and can spread apart from each other. |
| liquid | The state in which a substance adapts to the shape of its container and mostly maintains its volume. The particles are touching, but they can move past each other. |
| matter | Anything that has mass and takes up space. |
| mixture | A substance that contains two or more substances which are not chemically combined. |
| property | A characteristic of a material. |
| scientific inquiry process | A step-by-step process that scientists use to gather information about the world around us. |
| solid | The state in which a substance maintains a fixed volume and shape. The particles are packed closely together. |
| substance | Matter that has specific components and properties. |

### Possible Student Misconceptions

- **When a new substance is formed, it has the same properties as the original substances it is made up of**. New substances possess their own, unique set of properties. These properties are different from the properties of the original substances from which they were made.
- **Oil does not mix with water because oil is slippery and just glides along the water**. Oil does not mix with water because it is less dense. A teaspoon of oil has a smaller mass than a teaspoon of water. Since oil is less dense, it floats on top of the water.

## Procedure

### Part 1. Physical Properties

1. Direct students to access Activity 3 in the student course and have them read the Introduction.
2. Have students prepare their PLTW Launch Logs for Activity 3.
3. Lead a discussion to review the previous activities.

- What are some properties of solids? Liquids? Gases?
  Direct students to access the flashcard examples to review the vocabulary terms *property*, *solid*, *liquid*, and *gas*.
- How do substances change between the three states of matter? What happens when the substance changes states? Give examples to demonstrate your thinking.
  Direct students to access the flashcard examples to review the vocabulary terms *substance and matter.*
- How does conservation of mass relate to mixtures? What happens to mass when two substances are combined?
  Direct students to access the flashcard examples to review the vocabulary terms *conservation of mass*, *mixture*, and *mass*.

4. Model how to observe physical properties of matter.
   - Tell students that we can observe physical properties of matter using our five senses—sight, smell, hearing, taste, and touch.
   - Tell students to grab a pencil. Guide students to observe their pencil. Complete a Think-Pair-Share on each question, and use the Physical Properties of Matter chart to record students' thinking.

**Note**: Think-Pair-Share is a strategy where students think individually, discuss ideas with a partner, and then share with the whole class. It increases participation and focus.

- What does the pencil look like?
- What does it smell like?
- What sounds does it make when you use it?
- What do you think it would taste like?
- What does it feel like?

5. Distribute one paper clip to each group of students.
6. Direct the small groups of students to write down physical properties of the paper clip, and a second object of their choice, in their Launch Logs.
7. Lead a discussion about physical properties. Use the Physical Properties of Matter chart to record students' thinking.

What words can you use to describe the properties of a solid? A liquid? A gas?

Physical properties can include: Hard, soft, strong, weak, tough, brittle, stiff, rigid, flexible, absorbent, waterproof, magnetic, non-magnetic, smooth, rough, transparent, translucent, opaque

**Note**: In this activity, students are beginning to explore physical properties of matter, but they have not yet learned about specific properties. As you discuss properties of matter, introduce the idea that all matter can be described by its properties, such as color and hardness. Let them know that the investigations in this activity and the project will help them discover more about physical properties of matter such as:

- Compressibility
- Hardness
- Softness and firmness
- Fatigue strength
- Bend strength
- Elasticity
- Tensile strength

For more details, refer to Possible Student Misconceptions throughout the module.

## Part 2. New Substances

8. Tell students, we can expand upon their knowledge of physical properties of matter when mixing substances together.
9. Guide students to view the Mixtures presentation in the student course. They can view it in small groups or as a class.
10. Lead a discussion about the salad mixture.

- Which states of matter did you observe in the salad?
- What physical properties did you observe in the individual ingredients of the salad?
- Did the physical properties change when the ingredients were mixed together? Why or why not?
- If you did not like one of the ingredients, could you separate it from the salad mixture? Why or why not?

11. Direct students to view the Muffins Baking video in the student course. As students watch the video, have them consider:
    - Which states of matter are the muffins going through?
    - Can a baked muffin return to the forms of the original ingredients? Why or why not?

12 Lead a discussion about the video.

- When the batter was placed in the oven, which state was it in?
- What physical properties did the batter have?
- When the muffins came out of the oven, which state were they in?
- What physical properties did the baked muffins have?
- If you were allergic to one of the ingredients in the muffins, could you remove it after the muffins were baked? Why or why not?

13 Tell students the baked muffins are an example of a new substance. New substances are created when two or more substances are mixed together to form a substance with its own unique set of properties, different from the originals. This is the result of a chemical reaction, and it cannot be undone. Direct students to access the flashcard example to introduce the vocabulary term *chemical reaction*.

> **Note**: Students may struggle with the distinction between mixtures and new substances, in situations where one of the original substances is dissolved into the other, or in cases where students do not have the tools to separate them back to their original forms.
>
> For example, combining chocolate sauce and milk creates a mixture, but it does not form a new substance. A chemical reaction does not take place, and the chocolate sauce and the milk still retain their original properties when viewed under a microscope. You can see this when the chocolate milk mixture sits too long, in which case the chocolate starts to separate and collect in the bottom of the glass.
>
> This is a good time to also talk about evaporation, especially as a way of separating substances in a mixture. For example, while sugar and salt can dissolve in water, they cannot evaporate. If sugar or salt water is heated or left for a period, the water will evaporate and the sugar or salt will remain. You can help students activate their prior knowledge about this concept. Ask students who have swum in an ocean whether they ever dried off and still had salt on their skin.

14 Introduce the new substance investigations. In these investigations, students will determine whether a new substance is formed when mixing two different substances. Direct students to access the flashcard example to review the vocabulary term *scientific inquiry process*.

15 **Ask**: Guide students to ask questions so they can set up experiments to test and observe what happens.

- Ask students to share questions they have about mixing substances. Discuss which of their questions are testable.
- Present the testable question for this investigation: Will the mixtures of different substances result in a new substance?
- Direct students to record the testable question in their Launch Logs.

16 Hand out a New Substances worksheet to each student.

17 Direct students to observe the substances that will be used in the investigations. Guide small groups to use their five senses to observe each substance, then write down the physical properties of each on their New Substances worksheet. The substances include:

- Cooking oil
- Water
- Sand
- Iodized salt

18 **Predict**: Guide students to make predictions to answer the testable question.

- Guide students to gather the materials for each investigation.
- Direct students to record their predictions on their New Substances worksheet about whether a new substance will be formed. Have them provide an explanation for their thinking.
- Remind students that their predictions should be based on their prior knowledge about mixtures gained from past experiences and understanding.
- Lead a discussion about the students' predictions.

- Do you think oil and water will create a new substance when mixed? Why do you think this?
- Do you think sand and water will create a new substance when mixed? Why do you think this?
- Do you think salt and water will create a new substance when mixed? Why do you think this?
- Do you think baking soda and vinegar will create a new substance when mixed? Why do you think this?
- How do you think we can test your predictions?

19 To model how students will wear safety glasses throughout these investigations, put on your safety glasses. Direct students to put on their safety glasses.

20 **Investigate, Observe, and Explain**: Explain that students will test their predictions by carrying out four investigations. They will observe and collect data throughout each investigation and explain their results.

- Tell students to follow the procedures in the student course to conduct each investigation.
- Investigate
  - **Investigation 1**: Students mix 80 mL of water and 10 mL of cooking oil.
  - **Investigation 2**: Students mix 80 mL of water and 1 tbsp of sand.
  - **Investigation 3**: Students mix 80 mL of water and 1 tbsp of iodized salt.
  - **Investigation 4**: Students mix 50 mL of distilled white vinegar and 1 tbsp of baking soda.

- Observe: Students discuss their observations in their small groups. They consider:
  - Can you still see both substances?
  - Can you separate the substances from the mixture?
  - Do you observe any new properties? What are they? Explain your thinking.

  They record the properties of the mixture on their New Substances worksheet.
- Explain: Students discuss their findings in their small groups. They consider:
  - Was a new substance formed? Use evidence from the investigation to explain your thinking.
  - Was your prediction correct? Why or why not?

  Students record whether or not a new substance was formed on their New Substances worksheet.

21 As students complete the investigations, circle around the room and assess student progress. Ask students to share their ideas and thinking with you as they work. As you uncover misconceptions, work with students to use the investigations to build accurate conceptual understanding.

22 Remind students to clean their tools between each investigation.

23 Lead a discussion about their investigations.

- Did any of the substances maintain their properties after being mixed? Did they create a new substance? Explain your thinking.

  The following mixtures maintained their own properties, and did **not** create a new substance:
  - Oil and water
  - Sand and water
  - Salt and water

  Each of these mixtures can be separated into their original forms using various processes.

- Did any of the substances change their properties after being mixed? Did they create a new substance? Explain your thinking.

  The baking soda and vinegar mixture changed its properties and created a new substance. This was visible because bubbles formed, which meant the mixture changed into a gas.

- Did any of the mixtures lead to a chemical reaction? Use evidence from the investigation(s) to explain your thinking.

  The baking soda and vinegar mixture formed a new substance and lead to a chemical reaction. The chemical reaction was visible in the form of bubbles.

24 Optional: Mix iodized salt and water in a beaker to show this mixture does not form a new substance. Leave the beaker out in the classroom until the water evaporates, leaving the salt at the bottom. This will address misconceptions about why a new substance was not formed with this mixture, even though the iodized salt was not visible when mixed.

25 Guide students to answer the Conclusion Questions. Lead a discussion for students to share their thoughts.

## Conclusion Questions Answer Key

1 You decide to make toast for breakfast. You put two slices of bread in the toaster and walk away to get ready for school. After a while, you return to find that your toast is almost completely burned. What is one property that has changed? Do you think a new substance has been created? Explain your reasoning.

Student responses should demonstrate an understanding of new substances. Responses might include:
Several properties have changed, including the color of the bread and the texture (soft to crispy). It is a new substance because a chemical reaction has occurred. You cannot "un-toast" the bread. Burning the bread has released steam and energy, so it is a new substance.

2 Think back to the lemonade from Activity 2. You created it by mixing lemonade powder and water. Is the lemonade a new substance? Explain your reasoning.

Student responses should demonstrate an understanding of new substances. Responses might include:
The lemonade is not a new substance. Just like the salt and water I observed in this activity, the lemonade powder and water keep their original properties after being mixed together. The two substances could be separated using various processes.

Project

# Playing With Properties

Teacher Resources

View Student Course

## EQUIPMENT

The list below is based on a class of 30 students.

| Included in Equipment Kit | Not Included in Equipment Kit | Device Applications |
|---|---|---|
| • Safety glasses (31)<br>• Assorted compression springs (8)<br>• Phone screen covers (9)<br>• Nails (10)<br>• Foam (10 pieces)<br>• Resealable plastic bags (20)<br>• Digital scale | • PLTW Launch Logs (1 per student)<br>• Digital devices<br>• Pencils or colored pencils for sketching<br>• Plastic grocery bags (8)<br>• Paper grocery bags (8)<br>• Cloth grocery bags (8)<br>• Sand or other heavy items to create weights<br>• Heavy book<br>• Dry-erase markers (2)<br>• Poles, dowels, or brooms (2)<br>• Desks or chairs (4)<br>• Rulers (4) | • Inkling<br>• Camera<br>• Stopwatch<br>• Slow-motion video analysis, such as:<br>  ◦ SloPro<br>  ◦ Kapwing |

## ESSENTIAL QUESTIONS

EQ

EQ1 How do the structures and properties of matter help us solve real-world problems?
EQ2 How do mechanical properties impact engineering design?
EQ3 How can a step-by-step process help you design or improve a solution to a problem?

## LEARNING OBJECTIVES

LO

LO1.2 Use scientific reasoning to ask questions, make observations, and investigate ideas to make sense of phenomena and solve problems.
LO2.2 Make observations to describe materials based on their mechanical properties.
LO3.1 Apply mathematical thinking to solve problems.
LO4 Collaborate effectively on a diverse and multidisciplinary team.
LO5 Communicate effectively for specific purposes and settings.
LO6 Practice ethical behavior in all settings.

## KNOWLEDGE AND SKILLS

KS

KS1.2.3 Make observations to draw conclusions of phenomena.
KS1.2.4 Analyze data to look for patterns or to test whether data are consistent with an initial prediction.
KS1.2.5 Analyze models as an explanation of phenomena.
KS2.2.1 Describe how mechanical engineers use mechanical properties and testing in the real world.
KS2.2.2 Test mechanical properties with a variety of materials.
KS3.1.3 Use appropriate tools strategically. [CCSS.MATH.PRACTICE.MP5]
KS3.1.5 Use data to highlight or propose cause-and-effect relationships, predict outcomes, or communicate an idea. [CSTA 1B-DA-07]
KS4.1 Generate ideas as a team.
KS4.2 Value the contributions of each team member.
KS4.3 Demonstrate collaboration through effective communication.
KS5.1 Document work in an organized notebook.
KS5.2 Explain findings and justify evidence-based conclusions with others.
KS5.3 Present data and information accurately and effectively.
KS6.1 Engage in and maintain positive interactions and relationships with other children and adults.

# Preparation

## Professional Development

Before you facilitate the project, access the **Matter: Properties and Reactions Module-specific PD Resources** to review Building Your Understanding: Mechanical Properties.

## Part 1. Mechanical Engineering

1. Become familiar with mechanical engineering. Review the Mechanical Engineers presentation in the student course to become familiar with the content students will explore.
2. Consider using **other resources** with students to make career connections. For more information, see the Additional Instructional Resources in the Introduction to the Module.

## Part 2. Centers

1. Before you begin the project, gather items for the centers. The notes for each center prep below include the specific materials you need. Use the Family Letter in the Introduction to the Module to ask families for donations. Items you need to request can include sand; plastic, paper, and cloth grocery bags (8 of each); and to hang the grocery bags on such as poles, dowels, or brooms (2).

> **Note**: The centers in PLTW Launch are designed as a way for small groups to explore the learning activities independently.
>
> The number of centers you need for a class will vary depending on class size. The directions are written for a class size of 30 students. If your class is larger or smaller, adjust your centers accordingly. Students will work in small groups of two to four.
>
> Before you start, determine the best way to implement and set up centers for your students. You may decide that your students need additional background information or require an adult's assistance for a particular center. As you prepare the centers, consider, and plan for, any additional support your students may need.
>
> Guided exploration allows students to build knowledge that contributes to understanding mechanical properties. It is important that each student visit every center to acquire the skills necessary to complete the Problem.

2. Set up the centers as follows:
   - **Centers 1 and 5: Tensile Strength**
     - Set up this center to allow students to explore tensile strength.
     - To become familiar with the content students will explore, review the tensile strength section of the **Mechanical Properties** interactive experience.
     - To become familiar with the procedure students will experience, review the Tensile Testing Procedure in the student course.
     - Determine how students will hang the grocery bags. Use an item, such as a pole, dowel, or broom, and place it across two chairs or desks.



Example Setup for Tensile Strength Center

- Create your own weights. You may use the Family Letter to request donations of materials to use.
  - Add sand or other heavy items to fill at least 20 resealable plastic bags to create weights.
  - Use a digital scale to weigh each bag as you are filling it, so that each resealable plastic bag has the same mass.
- Place the materials at each center.
- Materials: PLTW Launch Logs, plastic grocery bags (4), paper grocery bags (4), cloth grocery bags (4), prepared weights (10), items on which to hang the grocery bags (such as poles, dowels, or brooms) (2), chairs or desks (2), safety glasses (1 pair per student), digital devices

> **Note**: During this center, students will add weights to the grocery bags, and they may break. Consider placing only one of each type of grocery bag at each center, until a new group rotates to this center.

- **Centers 2 and 6: Compressibility**
  - Set up this center to allow students to explore compressibility.
  - To become familiar with the content students will explore, review the compressibility section of the **Mechanical Properties** interactive experience.
  - To become familiar with the testing procedure students will experience, review the Compression Testing Procedure in the student course.
  - Place the materials at each center.
  - Materials: PLTW Launch Logs, assorted compression springs (4), ruler, safety glasses (1 pair per student), digital devices
- **Centers 3 and 7: Hardness**
  - Set up this center to allow students to explore hardness.
  - To become familiar with the content students will explore, review the hardness section of the **Mechanical Properties** interactive experience.
  - To become familiar with the testing procedure students will experience, review the Hardness Testing Procedure in the student course.
  - In this center, students choose a material to test the hardness of a phone screen cover. Alternatively, you could have items for materials to choose from such as keys, closed scissors, or other hard objects.
  - Place the materials at each center.
  - Materials: PLTW Launch Logs, phone screen covers (4), nails (5), dry-erase marker, safety glasses (1 pair per student), digital devices

> **Note**: During this center, students will scratch the phone screen covers. Each small group needs one phone screen cover. Consider only placing one phone screen cover at each center, until a new group rotates to this center.

- **Centers 4 and 8: Softness or Firmness**
  - Set up this center to allow students to explore softness and firmness.
  - To become familiar with the content students will explore, review the softness or firmness section of the **Mechanical Properties** interactive experience.
  - To become familiar with the testing procedure students will experience, review the Impact Testing Procedure in the student course.
  - Place the materials at each center.

- Materials: PLTW Launch Logs, foam (10 pieces), ruler, heavy book, safety glasses (1 pair per student), digital devices

> **Note**: During this center, students will drop the heavy book onto the foam. Each group needs one piece of foam. Consider placing only one piece of foam at each center, until a new group rotates to this center.

3. In Part 2, you will discuss recalls with students. Before leading this discussion, familiarize yourself with **examples of products** that have been recalled.

**Time**: 180 Minutes

## Introduction

In this project, students become *mechanical engineers* and use the same process engineers use to choose *materials* for their designs. They are introduced to *mechanical properties* and their application to engineering. They complete centers with *testing procedures* to explore the mechanical properties of *tensile strength*, *compressibility*, *hardness*, and *softness and firmness*. Students apply their knowledge of each of these mechanical properties to the real world.

| | |
|---|---|
| compressibility | The property of a material to get smaller when force or pressure is applied. |
| force | A push or pull that can make an object move, stop moving, change shape, or change directions. |
| hardness | The property of a material to be firm and solid, or not easy to bend, cut, or break. |
| impact | The action of one object coming forcibly into contact with another. |
| material | The matter from which a thing can be made. |
| mechanical engineer | A person who designs, constructs, and uses machines. |
| mechanical property | A physical property of a material when force is applied. |
| property | A characteristic of a material. |
| recall | A request from a manufacturer to return a product after the discovery of safety issues or product defects that might harm the consumer. |
| softness or firmness | The property of a material to support or resist a weight or a force. |
| tensile strength | The property of a material to be stretched or pulled without breaking. |
| testing procedure | A standardized and documented process for performing an experiment or conducting an evaluation. |

## Procedure

### Part 1. Mechanical Engineering

1. Direct students to access the project in the student course and have them read the Introduction.
2. Have students prepare their PLTW Launch Logs for the project.
3. Introduce the idea that properties can be applied to engineering design. Mechanical engineers are one type of engineers who use these properties of matter in their daily work, to choose the right materials for a design. Direct students to access the flashcard examples to review the vocabulary terms *property* and *material*, and introduce the vocabulary term *mechanical engineer*.
4. Guide students to view the Mechanical Engineers presentation in the student course. They can view it in small groups or as a class. Have students take notes in their Launch Logs while they read.
5. Lead a discussion about the presentation.

- Why are mechanical engineers important?
- How do mechanical engineers determine which materials to use in their designs?
- What types of products would need a mechanical engineer? Why do you think that?
- What role would a mechanical engineer have in designing a car?

### Part 2. Centers

7. Tell students that mechanical engineers use testing procedures to determine whether a material has the required mechanical properties. Direct students to access the flashcard example to introduce the vocabulary term *testing procedure*.

8. Introduce each of the following centers to the students in detail. Be sure to present new tools or equipment, such as how to hang the grocery bags, compress the springs, and scratch the phone screen covers. Introduce the testing procedures so students are familiar with how to follow the step-by-step directions.
   - **Centers 1 and 5: Tensile Strength**
     - Direct students to access the flashcard example as you introduce the vocabulary term *tensile strength*.
     - Students learn about tensile strength in the **Mechanical Properties** interactive experience.
     - Students follow the Tensile Testing Procedure to see which type of grocery bag has the greatest tensile strength.
     - Students use a chart to record how each grocery bag responds when weights are added.
   - **Centers 2 and 6: Compressibility**
     - Direct students to access the flashcard example as you introduce the vocabulary term *compressibility*.
     - Students learn about compressibility in the **Mechanical Properties** interactive experience.
     - Students follow the Compression Testing Procedure to see which type of spring has the greatest compressibility.
     - Students use a chart to record the lengths of the various springs before and after compression.
   - **Centers 3 and 7: Hardness**
     - Direct students to access the flashcard example as you introduce the vocabulary term *hardness*.
     - Students learn about hardness in the **Mechanical Properties** interactive experience.
     - Students follow the Hardness Testing Procedure to see the effects of scratching different materials on a phone screen cover.
     - Students use a chart to record whether or not the phone screen cover is affected by the different materials.
   - **Centers 4 and 8: Softness or Firmness**
     - Direct students to access the flashcard example as you introduce the vocabulary term *softness or firmness*.
     - Students learn about softness or firmness in the **Mechanical Properties** interactive experience.
     - Students follow the Impact Testing Procedure to see how a piece of foam can withstand different types of impact.
     - Students use a chart to record whether or not the foam was damaged after impact.
9. Put on your safety glasses to model how students will wear safety glasses throughout the centers.
10. Guide students to rotate through the four learning centers to explore more about mechanical properties. As previously noted, any of the center activities can be pulled out as separate activities to accommodate effective facilitation for your situation.
11. As students rotate through the centers, observe students interacting with the materials. Use the guiding questions at the end of each testing procedure in the student course to assess student learning throughout the project.
12. Lead students in a discussion of what they discovered through the centers.

    - Which grocery bag had the greatest tensile strength? What evidence do you have to support this?
    - What did you notice in the different springs as you compressed them? Were some able to return to their original shape and others not? How can you explain what you observed?
    - What did you discover about hardness? Why is it important to test hardness?
    - What did you discover about softness or firmness? Why is it important to test for this mechanical property?
    - Consider the foam in the soles of your shoes. How has your thinking about the materials used in your shoes changed after testing for softness or firmness?
    - What components or features did you notice were included in each type of testing procedure? Why do you think these are important to include?

    > **Note**: In the problem for this module, students will design their own testing procedure. The testing procedures they explored in this project serve as a model for what students will create in the problem. Some of the important components or features are:
    > - Identifying the mechanical property
    > - Identifying the material(s) that are being tested
    > - Determining the set up
    > - Determining the pass/fail conditions
    > - Measuring and recording observations of the materials before and after testing
    > - Carefully following step-by-step procedures
    > - Repeating the procedure using the same steps and controlled variables

13. Explain that testing procedures are important in evaluating materials for new and existing products. Tell students that a product can be recalled by the manufacturer if it does not work as it should, or if it poses a risk to our safety. Direct students to access the flashcard example as you introduce the vocabulary term *recall*.
14. Lead a discussion about recalls.

Do you know of any products or materials that have been recalled? What are they? Why do you think they were recalled?

- Stand2Learn™ Stool
  - Recalled because the feet are not properly welded and can break, causing a risk of falling.
- Fisher-Price™ Rock 'n Play™ Sleeper
  - Recalled because babies can roll over in it or get in a position where they cannot breathe.
- Rawlings™ Catcher's Helmet
  - Recalled because the back plate can fail and cause injury.

For additional examples of products that have been recalled, refer to the Recall List in the Additional Instructional Resources.

15 Direct students to discuss, with a partner or small group, the materials they worked with in the centers. Have them consider whether or not they would recall some of the materials. Encourage students to support their claims with evidence and record their answers in their Launch Logs.

16 Guide students to answer the Conclusion Questions. Lead a discussion for students to share their thoughts.

## Conclusion Questions Answer Key

1 You have been given a job to design a safe and effective airbag. Consider the four properties you tested in this activity. Select at least two properties to use to test the airbag and explain why they would be important in your design.

Student responses should demonstrate an understanding of mechanical properties. Responses might include:
Softness or firmness, tensile strength, and compressibility are most important when designing an airbag. An airbag has to be compressed into a small area in the steering wheel and then be able to expand in an accident. However, when it expands, it should still be somewhat soft, so it does not injure the driver or passenger on impact. It would also need a high tensile strength, so that it does not break when it is inflated.

2 Choose one product you use everyday such as a toothbrush, shoes, or a pencil. How can you improve this product through mechanical testing? Explain your answer.

Student responses should demonstrate an understanding of mechanical properties. Responses might include:
One product I use everyday is a mechanical pencil. Sometimes, the spring inside the pencil breaks after being compressed over a period of time. I would use a compression test to see which type of spring would work best in my mechanical pencil, so it can last for a long time.

Problem

# Mechanical Testing

Teacher Resources

View Student Course

## EQUIPMENT

The list below is based on a class of 30 students.

| Included in Equipment Kit | Not Included in Equipment Kit | Device Applications |
|---|---|---|
| • Safety glasses (31)<br>• #64 rubber bands (24)<br>• Binder clips (24)<br>• Cotton string<br>• C-clamps (8)<br>• VEX IQ® 1x Beam Base Pack<br>• VEX IQ Long Shaft Add-on Pack<br>• Resealable plastic bags (65)<br>• Measuring tapes (3-pack)<br>• Digital scale | • PLTW Launch Logs (1 per student)<br>• Digital devices<br>• Pencils or colored pencils for sketching<br>• Sand or other heavy items to create weights<br>• Measurement tools, such as:<br>  ◦ Rulers<br>  ◦ Meter sticks<br>  ◦ Yard sticks<br>• Optional: Other materials to use as weights, such as:<br>  ◦ Milk jugs<br>  ◦ Jars<br>• Optional:<br>  ◦ VEX IQ Construction Kits<br>  ◦ VEX IQ Robotics Kits | • Inkling<br>• Camera<br>• Digital product apps, such as:<br>  ◦ Popplet Lite<br>  ◦ Mindomo<br>  ◦ ShowMe Interactive Whiteboard |

## RESOURCES

R

Decision Matrix

Summative Assessment

## ESSENTIAL QUESTIONS

EQ

EQ1 How do the structures and properties of matter help us solve real-world problems?

EQ2 How do mechanical properties impact engineering design?

EQ3 How can a step-by-step process help you design or improve a solution to a problem?

## LEARNING OBJECTIVES

LO

LO1.1 Follow a step-by-step method to solve a problem.

LO2.2 Make observations to describe materials based on their mechanical properties.

LO3.1 Apply mathematical thinking to solve problems.

LO4 Collaborate effectively on a diverse and multidisciplinary team.

LO5 Communicate effectively for specific purposes and settings.

LO6 Practice ethical behavior in all settings.

KNOWLEDGE AND SKILLS — KS

| | |
|---|---|
| KS1.1.1 | Define a simple design problem reflecting a need or a want. |
| KS1.1.2 | Brainstorm possible solutions to the problem. |
| KS1.1.3 | Use evidence to compare and explain the effectiveness of different design solutions. |
| KS1.1.4 | Evaluate a model solution through observations and/or measurements and consider what revisions to the initial model are needed. |
| KS2.2.2 | Test mechanical properties with a variety of materials. |
| KS2.2.3 | Design a testing procedure that demonstrates whether a material has the required mechanical properties. |
| KS4.1 | Generate ideas as a team. |
| KS4.2 | Value the contributions of each team member. |
| KS4.3 | Demonstrate collaboration through effective communication. |
| KS5.1 | Document work in an organized notebook. |
| KS5.2 | Explain findings and justify evidence-based conclusions with others. |
| KS5.3 | Present data and information accurately and effectively. |
| KS6.1 | Engage in and maintain positive interactions and relationships with other children and adults. |

## Preparation

### Professional Development

Before you facilitate the problem, access the **Launchpad** to review:

- Thinking Like an Engineer
- Developing Research Skills with Elementary Students
- Integrating Technology and Promoting Online Safety
- Staying Safe and Secure! Interactive Experience

### Problem

1. In this problem, students work in groups to design a testing procedure for one of the mechanical properties introduced in the Introduction Story. These properties include: elasticity, fatigue strength, and bend strength. Plan how to group students, and assign or allow each group to select one of the properties.
2. For their testing procedures, students may decide they need weights. You can use the Family Letter to request donations of materials to use. To create your own weights, add sand or other heavy items to fill resealable plastic bags, milk jugs, or jars.
3. The focus of this problem is for students to design a testing procedure, rather than on the materials they are testing. However, students may use the materials as they evaluate their testing procedure. Determine how you will place the materials in the classroom for students to use.

   > **Note**: While the types of materials students can use in their testing procedures is open-ended, you may decide to have appropriate materials on hand for each mechanical property. The following are some materials students may want to use for their testing procedures:
   > - Elasticity Testing Procedure: Rubber bands, binder clips, string, measuring tape, meter or yard sticks
   > - Cyclic Fatigue Testing Procedure: Weights, VEX IQ 1x Beams, VEX IQ Shafts, C-clamps, string, rulers
   > - Bend Testing Procedure: Weights, VEX IQ 1x Beams, VEX IQ 1x Shafts, C-clamps, rulers

4. During the Explore step, students will read Chapter 2A, 2B, or 2C of the Introduction Story. Each group has a different chapter that sets up the problem their group will solve. To prepare for leading discussions with each group about their specific scenario, become familiar with the three versions of this chapter.
5. To help students design their own testing procedures, review the testing procedures students explored in the Project. Students can use the testing procedures in the Project as a model for what they are creating in this Problem.
6. As students work through the design process to develop a solution, use the Matter: Properties and Reactions Rubric to assess their demonstration of learning. You can access a printable version of the rubric in the Resources section on the **Summative Assessment** page. Use the rubric as a guide throughout the process of solving the problem.
7. Become familiar with the **Decision Matrix**. The decision matrix is a tool that allows students to rate the designs based on the criteria. If desired, you can print a copy of the decision matrix for each student to complete and glue in their Launch Log.

#### Possible Student Misconception

**Anything that stretches shows elasticity**. Elasticity is not a measure of how far something can stretch; it is a measure of how much something can stretch and then return to its original shape. There are many things that can stretch, but they do not go back to their original shape. For example, Silly Putty® does not have high elasticity because while it can stretch far, it stays in that stretched out position.

**Time**: 215 Minutes

## Introduction

In this problem, students work in small groups to build on their knowledge of the laws, states, and *properties* of *matter* by designing their own *testing procedure*. Using the *design process*, students research and design a procedure to test the *mechanical properties* of *elasticity*, *fatigue strength*, or *bend strength*. During the Evaluate step, students conduct a fair test to evaluate each others' designs.

| | |
|---|---|
| bend strength | The property of a material to curve without breaking. |
| compressibility | The property of a material to get smaller when force or pressure is applied. |
| constraint | A limitation or a restriction. Constraints can be limits on time, materials, and size. |
| criteria | Guidelines or rules used to judge or make a decision about something. |
| design process | A step-by-step way to solve problems. |
| elasticity | The property of a material to stretch and return to its original shape. |
| fatigue strength | The property of a material to withstand repeated weight or force before wearing out. |
| hardness | The property of a material to be firm and solid, or not easy to bend, cut, or break. |
| mechanical engineer | A person who designs, constructs, and uses machines. |
| mechanical property | A physical property of a material when force is applied. |
| softness or firmness | The property of a material to support or resist a weight or a force. |
| tensile strength | The property of a material to be stretched or pulled without breaking. |
| testing procedure | A standardized and documented process for performing an experiment or conducting an evaluation. |

## Procedure

1. Direct students to access the problem in the student course and have them read the Introduction.
2. Have students prepare their Launch Logs for the problem.
3. Lead a discussion to review testing procedures.

   - Why is mechanical testing so important?
   - What are some of the mechanical properties you tested in the project? How did you test them?
     Direct students to access the flashcard examples as you review the vocabulary terms *compressibility*, *hardness*, *softness or firmness*, and *tensile strength*.
   - What are some of the components that were part of the testing procedures you followed?
     Direct students to access the flashcard example as you review the vocabulary term *testing procedure*.

4. Direct students to access the flashcard example as you introduce the vocabulary term *design process*.
   - Ask students to share examples of how they have used a step-by-step process to complete a task. Examples include:
     - Getting ready for school
     - Brushing their teeth
     - Solving a math problem
     - Making a snack
   - Explain to the students that they are going to use the same steps that engineers use to design new items and improve existing items.
5. Present the Design Process video as an introduction to engineers and the design process.




Design Process video

6. Lead a discussion about what students learned from the Design Process video.

   - Why do engineers use the design process?
   - How do you think the design process helps engineers in their work?
   - Why is it important to ask questions as you work through the design process? Why do you think that?
   - In the video, we learned that it is important to understand the problem before looking for a solution. Have you ever identified a problem and then looked for a solution? Allow students to share their thoughts.

7. Guide students to locate the page in their Launch Logs titled, "Solving the Problem." Students use this section to take notes as they work through the design process to design a testing procedure. Remind students to include details that provide evidence for their thinking.

8. Introduce the problem to students. In this problem, students design a testing procedure to see whether a material has the required mechanical properties.

9. The first step in the design process is **Ask**.
   - Explain that to design a testing procedure, students must ask questions to gather information that will help them define the problem.

     - When you see a design such as a bridge, what questions do you ask yourself?
     - What questions would you want to ask a mechanical engineer regarding how they test the materials to construct that bridge? Direct students to access the flashcard example to review the vocabulary term *mechanical engineer*.

   - With support and guidance, the students define the problem, "How can we design a testing procedure to see whether a material has the required mechanical properties?"
   - Divide students into groups based on the mechanical properties you assigned in preparation. Tell groups the mechanical property they will be designing a testing procedure for. Alternatively, you may let groups choose. Direct students to access the flashcard examples to introduce the vocabulary terms *elasticity*, *bend strength*, and *fatigue strength*.
   - Direct each group to read their version of Chapter 2 of the Introduction Story: *Testing Things Out*.
     - Chapter 2A: *Elasticity*
     - Chapter 2B: *Fatigue Strength*
     - Chapter 2C: *Bend Strength*
   - With support and guidance, the students define their problem:
     - Elasticity: "How can we design an elasticity testing procedure to see whether a material has the required mechanical properties?"
     - Fatigue strength: "How can we design a cyclic fatigue testing procedure to see whether a material has the required mechanical properties?"
     - Bend strength: "How can we design a bend testing procedure to see whether a material has the required mechanical properties?"
   - Use the flashcard examples to introduce the vocabulary terms *criteria* and *constraint*.
   - Introduce the criteria and constraints of the design.

| Criteria | Constraints |
|---|---|
| The testing procedure:<br>• Has detailed step-by-step directions for completing the test<br>• Includes a list of equipment<br>• Has photos and/or drawings<br>• Includes a written description of the mechanical property<br>• Includes testing of at least one material<br>• Describes how to report and observe the data<br>• Uses a digital application to present the testing procedure | • Time<br>• Materials |

- Guide the students in a discussion to consider the problem, criteria, and constraints.
- Guide students to record their responses in the Ask step of their Launch Logs.
- Have students complete the self-reflection at the end of the Ask section in their Launch Logs. Guide students to circle one statement in each row. Assess student understanding and record comments as needed.

> **Note**: At the end of each stage of the design process, students complete a self-reflection. This self-reflection is intended for students to provide honest feedback about their skills during each stage. They are not expected to be "advanced" in all areas all the time. Explain to students that this self-reflection is intended to help them grow as problem-solvers.

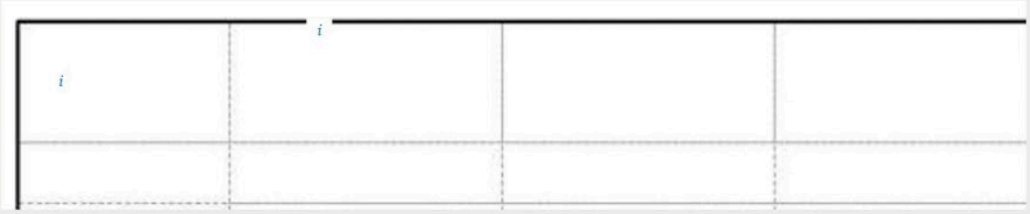
10 The second step in the design process is **Explore**.

- Guide students to review the section of the **Mechanical Properties** interactive experience that addresses their group's mechanical property.
- Have students record their notes and research findings from the interactive experience in their Launch Logs.
- Guide students to brainstorm several ideas that may solve the problem. Direct students to consider the testing procedures they explored in the Project as a guide for what they are creating in the Problem. Students may use the skills and knowledge they gained from the activities and project in this module, as well as information they gathered from their research.
- In the corresponding section of their Launch Logs, students record ideas and label sketches for their solution.
- Guide students to share their initial ideas with their group. Encourage them to add any new ideas by writing or sketching in their Launch Logs.
- Have students complete the self-reflection at the end of the Explore section in their Launch Logs. Assess student understanding and record comments as needed.

11 The third step in the design process is **Model**.

- Introduce a decision matrix as a way to decide on the best testing procedure. Using the **Decision Matrix**, students rate each group member's testing procedure based on a 0–1 scale for each category. If the testing procedure does not meet the criterion in a category, it receives a 0 in that category. If the testing procedure does meet the criterion, it receives a 1. The testing procedure with the highest total score offers the best solution from the group.

> **Note**: Students may use the decision matrix in their Launch Logs or the copy you provide. If they use the one in their Launch Logs, they need to complete the column and row headers as shown.




- Model how students will wear safety glasses throughout the design, construction, and evaluation of their test by putting on your safety glasses. Direct students to wear their safety glasses as they design their test.
- Guide students to use the chosen solution to create their testing procedure.

> **Note**: Remind students that the task is to design a testing procedure. They should not focus on whether a material will pass or fail, but rather focus on the details in the testing procedure itself. They can choose any materials that will best represent their mechanical property.

- Remind students to revisit the criteria so their testing procedure contains all elements.
- To facilitate creation of the testing procedures, circle around the room and assess student progress. Ask students to share their ideas and their thinking with you as they work.
- Have students complete the self-reflection at the end of the Model section in their Launch Logs. Assess student understanding and record comments as needed.

12 The fourth step in the design process is **Evaluate**.

- Explain to students that they will conduct a fair test to determine how well their model solves the problem. This fair test allows them to evaluate the testing procedure to see whether it tests the desired mechanical property.
- Guide students to work with their group to test their procedure, using the testing procedure they created in the Model step.

- Allow time for groups to make revisions, if necessary.
- Direct students to swap testing procedures with another group. Allow time for each group to try each other's test. Direct students to wear safety glasses as they conduct each other's testing procedures.
- Guide groups to give each other feedback on the strengths and weaknesses of their testing procedures.
- Guide students to reflect on the strengths and weaknesses of their testing procedure. Have them consider:
  - Did your testing procedure solve the design problem?
  - Were your steps thorough enough for others to perform the test as indicated?
  - What can you do to improve your testing procedure?
- After students identify the strengths and weaknesses of their testing procedure, allow time to revise it and make it better.
- Have students complete the self-reflection at the end of the Evaluate section in their Launch Logs. Assess student understanding and record comments as needed.

13 The fifth step in the design process is **Explain**.

- Provide time for students to plan how to share their testing procedures. They should include:
  - The mechanical property they were testing
  - The equipment and procedure used to test that mechanical property
  - A photograph or video
  - The results of the fair test used to test their design
- Allow students to present their designs to the class.
- After all presentations, lead a discussion about the different testing procedures.



- How do you know whether your testing procedure works to test the mechanical property?
- What other materials could you have used in your testing procedure?
- If you could improve anything about your testing procedure, what would you improve? Why would you improve that aspect?
- If you could design another testing procedure, which mechanical property would you want to test for? Why would you test that one?

- Guide students to complete the Explain section of their Launch Logs. Have students provide suggestions for improvement to their testing procedure and support those with evidence.
- Have students complete the self-reflection at the end of the Explain section in their Launch Logs. Then assess student understanding and record comments as needed.

14 Guide students to answer the Conclusion Questions. Lead a discussion for students to share their thoughts.

15 Direct students to complete the Matter: Properties and Reactions Check for Understanding. You can access a printable version of this assessment in the Resources section of the **Summative Assessment** page.

## Conclusion Questions Answer Key

1 Describe how successful your group's testing procedure was in meeting the criteria for the problem. Support your answer with evidence you recorded in your Launch Log.

Student responses will vary.

2 What changes would you make to improve the testing procedure? Why do you think these changes would improve your design?

Student responses will vary.

3 In this problem you designed a procedure for testing elasticity, bend strength, or fatigue strength. Reflect on how your testing procedures could be used to develop a new product. What kind of product could benefit from your testing procedure? Explain your thinking.

Student responses will vary.

Introduction to the Module

# Patterns in the Universe

Teacher Resources



**Distance Learning Support**

For information about PLTW's distance learning support and online learning guides, jump to Distance Learning Support in **PLTW Launch Module-specific PD Resources**.

For distance learning support for facilitating this module, jump to **Distance Learning Support: Patterns in the Universe Teacher Guide**.

## PREFACE

**Time**: 10 instructional hours

In this module, students become astronomers as they explore the Sun, Moon, Earth, and the stars beyond our solar system. Students learn how the brightness and distance of stars affect their appearance in the sky. Then, students use the scientific inquiry process to investigate predictable patterns in the universe, such as shadows, day and night, the Moon's phases, and the seasons.

After building an understanding of Earth's patterns and place in the universe, students follow the design process to research, design, and evaluate an exhibit that teaches and engages an audience on a topic of space science. To share what they have learned, students present their exhibit to classmates, friends, and/or family as they teach them about the wonders of space.

## TRANSFERS

T

T1 Evaluate a problem in a new and novel situation.
T2 Apply a step-by-step design process to solve a problem.
T3 Understand there are predictable patterns due to Earth's position in the universe.

## ESSENTIAL QUESTIONS

EQ

EQ1 What is Earth's place in the universe?
EQ2 How do the predictable patterns of Earth impact our lives?
EQ3 How can a step-by-step process help you design or improve a solution to a problem?

## UNDERSTANDINGS

U

U1 Scientists and engineers use standard practices to explain the world or solve problems.
U2 The universe includes all stars and planets in space. Earth is part of a solar system within the universe.
U3 Patterns are consistent and can be observed.
U4 Mathematical thinkers apply complex thinking and reasoning strategies where thinking is intentional and reflected upon.
U5 Professionals function effectively and efficiently on multidisciplinary teams to be successful.
U6 Professionals communicate effectively with a variety of audiences using multiple modalities to be successful.
U7 Professionals conduct themselves so as to maximize benefits for society and minimize harm.

## LEARNING OBJECTIVES — LO

- LO1.1 Follow a step-by-step method to solve a problem.
- LO1.2 Use scientific reasoning to ask questions, make observations, and investigate ideas to acquire knowledge and solve problems.
- LO2.1 Compare and contrast the Sun to other stars.
- LO2.2 Understand the universe includes all the natural bodies in space.
- LO3 Identify the observable patterns that occur related to Earth.
- LO4 Apply mathematical thinking to solve problems.
- LO5 Collaborate effectively on a diverse and multidisciplinary team.
- LO6 Communicate effectively for specific purposes and settings.
- LO7 Practice ethical behavior in all settings.

## KNOWLEDGE AND SKILLS — KS

- KS1.1.1 Define a simple design problem reflecting a need or a want.
- KS1.1.2 Brainstorm possible solutions to the problem.
- KS1.1.3 Evaluate a solution through observations and/or measurements and consider what revisions to the initial solution are needed.
- KS1.1.4 Identify the evidence that supports particular points in an explanation.
- KS1.2.1 Ask and identify questions to gain knowledge or solve problems.
- KS1.2.2 Make observations to draw conclusions of phenomena.
- KS1.2.3 Analyze data to look for patterns or to test whether data are consistent with an initial prediction.
- KS2.1.1 Identify what a star is.
- KS2.1.2 Understand that the Sun is a star.
- KS2.1.3 Understand that some stars appear brighter due to their relative distance from Earth.
- KS2.1.4 Develop a basic understanding of apparent magnitude and absolute magnitude of stars.
- KS2.2.1 Develop a basic understanding of Earth's place in the universe.
- KS2.2.2 Create an interactive, space science exhibit to share with an audience.
- KS3.1 Develop an understanding of shadows and why they change throughout the day.
- KS3.2 Explain the observable phenomena of day and night, daily changes in the direction and length of shadows, and different positions of the Sun, Moon, and stars at different times of the day, month, and year.
- KS3.3 Explain how Earth rotates on an axis.
- KS3.4 Explain how Earth orbits the Sun.
- KS3.5 Explain how the Moon orbits Earth.
- KS4.1 Make sense of problems and persevere in solving them. [CCSS.MATH.PRACTICE.MP1]
- KS4.2 Reason abstractly and quantitatively. [CCSS.MATH.PRACTICE.MP2]
- KS4.3 Construct viable arguments and critique the reasoning of others. [CCSS.MATH.PRACTICE.MP3]
- KS4.4 Model with mathematics. [CCSS.MATH.PRACTICE.MP4]
- KS4.5 Attend to precision. [CCSS.MATH.PRACTICE.MP6]
- KS4.6 Represent data in graphical displays to reveal patterns.
- KS4.7 Organize and present collected data visually to highlight relationships and support a claim. [CSTA 1B-DA-06]
- KS4.8 Use data to highlight or propose cause-and-effect relationships, predict outcomes, or communicate an idea. [CSTA 1B-DA-07]
- KS5.1 Generate ideas as a team.
- KS5.2 Value the contributions of each team member.
- KS5.3 Demonstrate collaboration through effective communication.
- KS6.1 Document work in an organized notebook.
- KS6.2 Explain findings and justify evidence-based conclusions with others.
- KS6.3 Present data and information accurately and effectively.
- KS6.4 Critique the explanations or solutions proposed by other students by citing evidence about the natural and designed world(s).
- KS7.1 Engage in and maintain positive interactions and relationships with other children and adults.

RESOURCES

R

- Curriculum Framework
- Connections to Standards
- Fifth Grade Connections to Standards
- Family Letter
- Additional Instructional Resources
- Fifth Grade Curriculum Revisions
- Device Specifications
- Application List

# Preparation

## Curriculum Framework and Connections to Standards

Before you facilitate this module, review the Curriculum Framework and Connections to Standards documents.

Standards are the foundation for what is taught in a classroom. They outline what students are expected to learn and be able to do as a result of participating in learning experiences. When planning the implementation of any curriculum, it is essential to identify which standards the curriculum addresses and any standards it does not. This offers greater insight into what the curriculum provides your students and any standards that you may need to address beyond the content provided.

For each PLTW Launch module, teachers are provided a curriculum framework document, which offers a three-stage approach to curriculum planning, assessment, and instruction. The framework document offers a big picture view of the module including the desired results of student learning, assessment opportunities that call for evidence of student learning, and an overview of the scaffolded approach to student learning.

Within the desired results of student learning in the curriculum framework, information is included about module connections to the following standards, when applicable:

- Next Generation Science Standards (NGSS)
- Common Core State Standards (CCSS) in English/Language Arts (ELA) and Mathematics
- Computer Science Teachers Association K–12 Computer Science Standards (CSTA)
- International Society for Technology in Education (ISTE)
- National Association for the Education of Young Children (NAEYC) Early Learning Program Standards
- Head Start Early Learning Outcomes Framework

We understand that your state might not align to these bodies of standards. That is why PLTW Launch is designed for flexible implementation. If your state does not address these standards, spend time comparing your state standards to those identified for the module. Remember that PLTW Launch modules can be implemented at any PreK–5 grade level based on your state standards. Also keep in mind that if you implement a module at a different grade level than indicated, you might need to make modifications to meet the needs of your students.

Exploring this framework resource before you examine the Teacher Guide gives you a high-level understanding of the stages to curriculum planning, assessment, and instruction. You can also determine how the module connects to the required standards for your state. After you have explored the curriculum framework document, you'll be ready to explore the step-by-step instructions in the Teacher Guide.

## Professional Development PD

### Resources

Before you facilitate the Patterns in the Universe module, review the professional development resources.

- Access the **Launchpad** to review:
  - Three Dimensional Learning
  - Claims and Evidence
  - The Teacher as Facilitator
  - PLTW Formative Assessment
  - Using PLTW Launch Logs
  - Uncovering and Addressing Misconceptions
  - The APB Instructional Approach
  - Setting the Stage for APB Learning
  - Thinking Like an Engineer
  - Developing Research Skills with Elementary Students
  - The Design Process Song: Version 1
  - The Design Process Song: Version 2
- Access the **Patterns in the Universe Module-specific PD Resources** to review:
  - Patterns in the Universe APB Overview
  - Patterns in the Universe Module Introduction

### Questioning Skills

As you facilitate APB learning, asking probing questions is essential. Within each activity, project, and problem throughout this Teacher Guide, you will notice sample prompts to ask your class. The prompts guide you to ask thought-provoking questions, as well as to identify conceptions and misconceptions.

As you work with your students, remember that you are not limited to the prompts provided. The best way to determine the types of questions to ask your students comes from observing and interacting with your students as they engage in the module. This provides formative assessment of students' conceptual development and allows you to uncover and address misconceptions.

Building your questioning skills increases your capacity to facilitate powerful student learning. For more information, review the following professional development resources in the **Launchpad**:

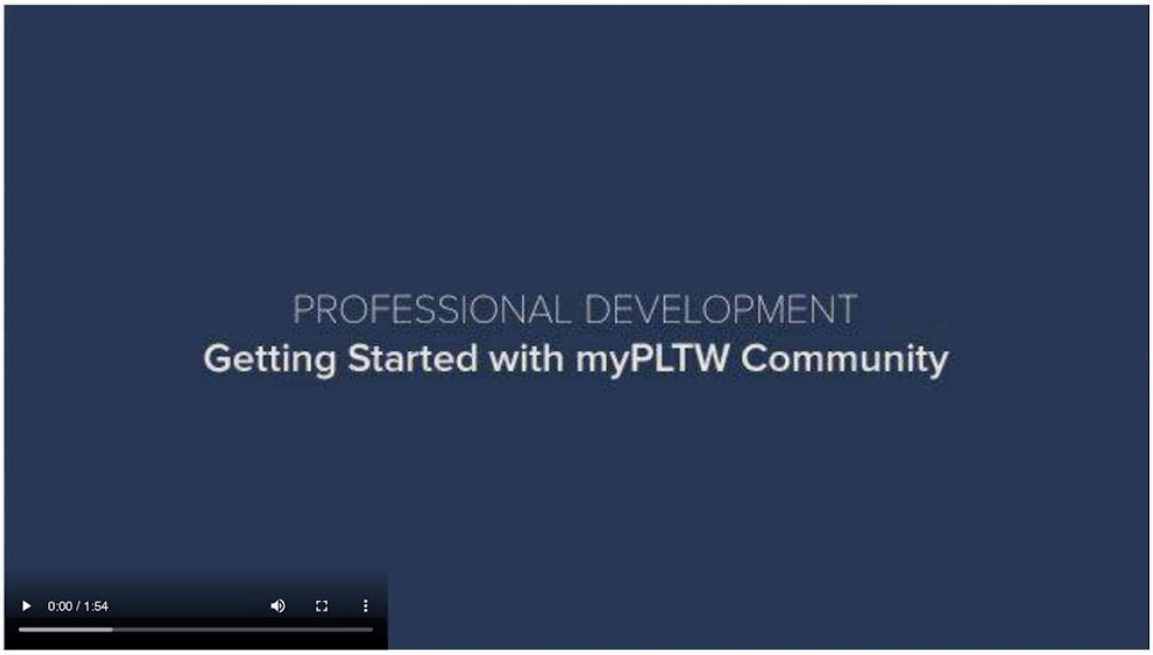
- The Art of Questioning

- Building Your Questioning Skills

## Community

As a PLTW Launch Classroom teacher, you are enrolled in discussion groups that allow you to network with other teachers. These discussion groups are in the Community tool in myPLTW. In these groups, you can communicate with other teachers about topics such as general information, modules, and equipment and software. You also have the opportunity to share success stories.

Before you facilitate a module, it is a good idea to review the posts in the groups to gather helpful information from teachers who have previously taught the module. If you have specific questions or comments to make, these discussion groups are a great way to connect with the PLTW Launch network.




Getting Started with myPLTW Community video

## Family and Community Relationships

Family and community relationships are encouraged throughout the module. A **Family Letter** is provided to introduce Project Lead The Way to families, ask for donations to complete specific activities, projects, or problems, and encourage families to support students' learning of concepts at home. PLTW recommends that you send this letter to families before you begin a module, to let them know what their students will be learning in school. A section titled "Dealing with Misconceptions" is also provided in the letter, so families can gain an understanding of the concepts introduced within the module.

FAMILY CONNECTION

Throughout the module, each activity, project, and problem includes a Family Connection section identified by this house icon. These sections provide activities families can do to support what students are learning. Families can use the log-in information provided in the Family Letter to access the course activities.

Consider ways in which you can establish community relationships throughout the Patterns in the Universe module. To encourage career connections in the classroom, you could invite speakers, such as astronomers, atmospheric scientists, aerospace engineers, astronauts, museum curators, or planetarium directors, to talk about the universe.

**Tip**: Prepare visitors for ways to best work with young children, such as:

- Bring items for students to touch
- Use visuals
- Keep dialogue short and simple
- Introduce new terms

## PLTW Launch Logs

As students progress through each module, they use PLTW Launch Logs to record their thinking, ideas, observations, and designs. The PLTW Launch Log is not a traditional workbook nor a collection of worksheets; rather it's designed to be an age-appropriate version of an engineering notebook. In the PLTW Launch Logs, students document their learning as they draw and write their ideas.

As the teacher, you can easily use this record of student ideas for formative assessment by evaluating students' demonstrations of their thinking and conceptual understanding. Allowing students to explain the thinking behind their responses to prompts is an invaluable way to uncover misconceptions and guide students to conceptual understanding. To gain a deeper understanding of the purpose and use of PLTW Launch Logs, access the "Using PLTW Launch Logs" professional development resource in the **Launchpad**.

## Developing Vocabulary

Vocabulary learning has been found most effective when active engagement with a term goes beyond just knowing the definition. Rather than presented in isolated lessons, vocabulary is introduced within the context of the activities, project, and problem. Viewing the course on a digital device, students have as-needed access to a glossary and interactive flashcards. Each card has an audio component, so students can independently review these words throughout the module.




▶ 0:00 / 0:07

## Icon Legend

Throughout the Teacher Guide, the following icons have special meanings.



### Digital Device

The Digital Device icon indicates times when you or your students will use a device for a learning experience.



### Camera

The Camera icon indicates when you or your students will use a camera for a learning experience. There are many camera options. When possible, the best option is for the students to use the camera on their digital device. However, you might need to assign a class photographer to use a digital camera, or you may be the photographer with the camera on your smartphone.




### Professional Development

The Professional Development (PD) icon indicates when a resource is available to provide additional information to you as a teacher. You can find these resources in the PLTW Launch Module-specific PD Resources course.

## Additional Instructional Resources

Project Lead The Way understands the importance of introducing literature, music, and rhyme to students. As such, we created a list of **additional resources** specific to this module. These resources are not included in the equipment kit, and they are not covered in the 10 instructional hours of the module. Incorporating the resources is optional, but they offer ways to provide additional engagement with the concepts explored in this module.

## Curriculum Revisions

The Launch curriculum is continuously updated to provide content and instructional resources that are current and based on best practices. Significant revisions to the curriculum implemented since the prior release of Launch are documented in the **Fifth Grade Curriculum Revisions**.

Introduction Story

# A Shooting Star

Teacher Resources

View Student Course

RESOURCE

R

Introduction Story: A Shooting Star

**Time**: 20 Minutes

## Introduction

To set the stage for learning, guide students to read the Introduction Story: *A Shooting Star*, a fictional story that introduces the problem. You may print the story if needed.

1. Introduce students to the student course and assist them with the log-in process on a digital device. For the rest of the module, students will access the curriculum in the student course.
2. Guide students to access the Introduction Story: *A Shooting Star*. Students can read or listen to the story using audio in small groups. Alternatively, you may read the story aloud as a class.
3. Use the guiding questions within the story to engage students in thinking about ideas and concepts throughout the module. Use this time of discussion to uncover what your students already know about the concepts, what they are curious about, and what misconceptions they have. Consider how this formative assessment of students can guide you as you facilitate the activities, project, and problem in this module.
4. To set the purpose for the learning experiences to come, it is important to guide students to identify the problem. Throughout the module, students can reread the story to remind themselves of the problem they will be solving.

Activity 1

# What Is a Star?

Teacher Resources

View Student Course

## EQUIPMENT

This list is based on a class of 30 students.

| Not Included in Equipment Kit | Device Applications |
|---|---|
| • PLTW Launch Logs (1 per student)<br>• Digital devices<br>• Pencils or colored pencils for sketching<br>• Chart paper<br>• Markers | • Inkling<br>• Star Chart |

## RESOURCE

R

Grades 3–5 Launch Log

## ESSENTIAL QUESTIONS

EQ

EQ1 What is Earth's place in the universe?
EQ2 How do the predictable patterns of Earth impact our lives?
EQ3 How can a step-by-step process help you design or improve a solution to a problem?

## LEARNING OBJECTIVES

LO

LO1.2 Use scientific reasoning to ask questions, make observations, and investigate ideas to acquire knowledge and solve problems.
LO2.1 Compare and contrast the Sun to other stars.
LO2.2 Understand the universe includes all the natural bodies in space.
LO4 Apply mathematical thinking to solve problems.
LO5 Collaborate effectively on a diverse and multidisciplinary team.
LO6 Communicate effectively for specific purposes and settings.
LO7 Practice ethical behavior in all settings.

## KNOWLEDGE AND SKILLS

KS

| | |
|---|---|
| KS1.2.1 | Ask and identify questions to gain knowledge or solve problems. |
| KS1.2.2 | Make observations to draw conclusions of phenomena. |
| KS1.2.3 | Analyze data to look for patterns or to test whether data are consistent with an initial prediction. |
| KS2.1.1 | Identify what a star is. |
| KS2.1.2 | Understand that the Sun is a star. |
| KS2.1.3 | Understand that some stars appear brighter due to their relative distance from Earth. |
| KS2.1.4 | Develop a basic understanding of apparent magnitude and absolute magnitude of stars. |
| KS2.2.1 | Develop a basic understanding of Earth's place in the universe. |
| KS4.2 | Reason abstractly and quantitatively. [CCSS.MATH.PRACTICE.MP2] |
| KS4.3 | Construct viable arguments and critique the reasoning of others. [CCSS.MATH.PRACTICE.MP3] |
| KS4.5 | Attend to precision. [CCSS.MATH.PRACTICE.MP6] |
| KS4.7 | Organize and present collected data visually to highlight relationships and support a claim. [CSTA 1B-DA-06] |
| KS4.8 | Use data to highlight or propose cause-and-effect relationships, predict outcomes, or communicate an idea. [CSTA 1B-DA-07] |
| KS5.1 | Generate ideas as a team. |
| KS5.2 | Value the contributions of each team member. |
| KS5.3 | Demonstrate collaboration through effective communication. |
| KS6.1 | Document work in an organized notebook. |
| KS6.2 | Explain findings and justify evidence-based conclusions with others. |
| KS6.3 | Present data and information accurately and effectively. |
| KS6.4 | Critique the explanations or solutions proposed by other students by citing evidence about the natural and designed world(s). |
| KS7.1 | Engage in and maintain positive interactions and relationships with other children and adults. |

# Preparation

## Professional Development

Before you facilitate Activity 1, access the **Patterns in the Universe Module-specific PD Resources** to review:

- Building Your Understanding: Earth's Place in the Universe
- Building Your Understanding: Patterns of the Sun
- Building Your Understanding: Light Waves
- Building Your Understanding: How Light Waves Travel

## Part 1. Stars

1. Before you begin Activity 1, read the **Introduction Story: *A Shooting Star*** with students.
2. Use a piece of chart paper to prepare a KWL chart titled "Stars".

| Stars | | |
|---|---|---|
| K | W | L |
| What do you know? | What do you want to learn? | What did you learn? |
| | | |

## Part 2. Stars in the Sky

Before you begin Part 2, review the Stars in the Sky presentation to become familiar with how stars are formed, how they are classified, and what happens at the end of their lives.

## Part 3. Brightness of Stars

Before you begin Part 3, become familiar with the Star Chart app. Review the Procedure so you understand how to search for a specific star.

**Time**: 60 Minutes

# Introduction

The night sky, filled with sparkling *stars* and streaking comets, has captivated humans for centuries. The mysteries of the stars inspire us to learn more about our planet and the universe beyond, leading to countless scientific discoveries!

In this activity, students begin their own exploration of the wonders of the cosmos as they learn about stars. Students discover that stars are balls of hot gases and come in different shapes and sizes. They learn that the star at the center of our *solar system* is called the *Sun*.

Students examine how far some stars are from Earth and how this distance, along with the brightness of the star, affects its appearance in our night sky. By comparing and contrasting stars, students begin to develop an understanding of Earth's place in the universe.

| | |
|---|---|
| absolute magnitude | A measurement of how bright stars would appear if all stars were the same distance from Earth; also known as luminosity. |
| apparent magnitude | A measurement of how bright a star appears from Earth. |
| evidence | Information that explains or supports a claim. |
| orbit (noun) | The curved path of an object around a star, planet, or moon. |
| orbit (verb) | To move around a larger object in space. |
| star | A huge sphere of very hot, glowing gas that produces its own light. |
| solar system | The system of planets, including Earth, moons, and other bodies that orbit the Sun. |
| Sun | The star at the center of our solar system. |

### Possible Student Misconceptions

- **The Sun is not a star**. "Sun" is the name of the star at the center of our solar system. It is a hot ball of glowing gases called a yellow dwarf star. We know it is a star, instead of a planet, comet, or asteroid, because it emits light and other particles only emitted by stars.
- **The Sun is the largest star in the universe**. The Sun is the largest, and only, star in our solar system. There are much bigger stars than the Sun, but all the other stars we see are very far away. Our sun is a medium-sized star.
- **Stars are pointy**. Stars appear pointy in scientific photographs due to the way that telescopes collect and bend the light from the star. When looking directly up into the night sky, stars do not appear pointy. They look like circles. This is because stars are spherical.
- **Stars blink on and off to twinkle**. When looking at stars in the night sky, they appear to twinkle. They are not actually blinking on and off. Instead, the stars in our sky are so far away that only a little bit of light reaches our eyes, and this small amount of light can easily be interrupted or change direction as it makes its way through our atmosphere. This causes the twinkling appearance.
- **The solar system is the entire universe**. Our solar system contains the Sun and all the planets, moons, and asteroids held by the gravity of the Sun. Beyond Neptune, our solar system is surrounded by icy rocks called the Oort Cloud. This is as far as our solar system extends. Because we observe stars, planets, and other objects beyond this point, we know that the universe expands beyond our solar system.

## Procedure

### Part 1. Stars

1. Direct students to access Activity 1 in the student course and have them read the Introduction.
2. Lead a discussion of the questions in the Introduction. This discussion provides an opportunity for formative assessment as students share their conceptions about stars.

   - What is a star? Why do you think this? Direct students to access the flashcard example as you introduce the vocabulary term *star*.
   - Why do you think stars twinkle?
   - Which star is located within our solar system? Direct students to access the flashcard example as you introduce the vocabulary term *solar system*.

   As you work through this activity, continue to ask questions to determine whether students' misconceptions are being addressed through the hands-on activities.
3. Students use PLTW Launch Logs to keep a record of their work as they progress through the module. Distribute a Grades 3–5 Launch Log to each student. In their notebooks, they can take notes as they research, create sketches, and answer conclusion questions.
4. Have students prepare their PLTW Launch Logs for Activity 1.
5. Introduce the students to the KWL graphic organizer. This graphic organizer will be used to record what the students already know about stars, what they want to learn, and what they learn from this module.
6. Guide students to create a KWL chart in their Launch Logs titled "Stars".
7. Have students work individually, with a partner, or in a small group to complete the first two columns in the KWL chart with their responses about stars. All students, whether working individually or with a partner or group, should create the chart and record their responses in their own Launch Logs.
8. Monitor student groups as they fill out the KWL chart. Look for misconceptions that may be uncovered as they record their ideas. Allow time for groups to share their responses in the first two columns.
9. Record the student responses in the class KWL chart titled "Stars".

### Part 2. Stars in the Sky

10. Introduce the Stars in the Sky presentation. Guide students to work with a partner or small group to view the presentation to build an understanding of stars. Have students take notes in the "L" column of their KWL chart in their Launch Logs while they view the presentation.




Stars in the Sky video

11 Lead a discussion about the presentation. Add responses to the class KWL chart.

- How are stars similar or different from one another?
- Where do stars come from?
- What happens at the end of a star's life?
- What star is in our solar system?
  Direct students to access the flashcard example as you introduce the vocabulary term *Sun*.
- Why is the Sun important to Earth? Why do you think that?

## Part 3. Brightness of Stars

12 Guide students to view the photograph of the night sky in the student course.

13 Guide students to complete a Think-Pair-Share on the following questions:

- Why do some stars appear brighter in the night sky?
- If the Sun is a star just like the stars in our night sky, why is it so much brighter?

**Note**: Think-Pair-Share is a strategy where students think individually, discuss ideas with a partner, and then share with the whole class. It increases participation and focus.

14 Explain to students that they will use the Star Chart app to view specific stars. Model how to search for the star, Rigel.

- Select the magnifying glass in the bottom right corner to search.
- Select the **Stars** icon at the bottom of the search panel.
- In the menu, select the new magnifying glass. Type "Rigel" and select **Search**.
- Select **Rigel** in the search panel. This brings you to the sky view and centers the star on your screen.
- To close the Sky Search menu, select **Back**.

15 Lead a discussion about the apparent brightness of Rigel.

Do you think Rigel appears bright? Medium bright? Dim? Why do you think this?

16 Zoom out from Rigel and ask students to compare its brightness to the brightness of other stars.

17 Tell students they are going to record three facts about stars:

- Distance in light-years (ly). A light-year is a unit of distance equal to the distance that light travels in one Earth year, which is about six trillion miles.
- Absolute magnitude (Abs Mag). Direct students to access the flashcard example as you introduce the vocabulary term *absolute magnitude*.
- Apparent magnitude (App Mag). Apparent magnitude is how bright a star appears from Earth. Direct students to access the flashcard example as you introduce the vocabulary term *apparent magnitude*.

18 Guide students to create a chart in their Launch Logs to record brightness (bright, medium bright, or dim), distance, absolute magnitude, and apparent magnitude for five stars: Polaris, Sirius, Betelgeuse, Mirach, and Arcturus.

| Name of Star | Brightness | Distance in Light-years | Absolute Magnitude | Apparent Magnitude |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| Polaris | | | | |
| Sirius | | | | |
| Betelgeuse | | | | |
| Mirach | | | | |
| Arcturus | | | | |

19 Direct students to work in a small group and use the Star Chart app to complete the chart in their Launch Log.

20 Lead a discussion with students about their findings. Ask students to provide evidence to support their answers.

**Note**: When you lead a discussion, it is valuable to begin to use the terms **claims** and **evidence** with students.

When students are asked a question, guide them to make a **claim** followed by **evidence**. A **claim** is a statement about something that answers a question. **Evidence** includes facts or observations that support the claim.

- Claim statement: "I think (or know) that..."
- Evidence statement: "I think (or know) this, because I observed (or have done)..."

If a student makes a statement, but does not support their claim with evidence, use the following questions to encourage the development of an evidence statement.

- Why do you think that?
- What have you seen or done that makes you think that?
- What evidence do you have that supports your claim?
- Is there anything that made you think that?

Students' evidence may be based on their experiences, observations, or ideas they have learned. As discussions are held, student misconceptions may arise. Be sure to address misconceptions at this time.

- Which star seemed the brightest? Why do you think it is so bright?
- Are the closest stars the brightest stars? Support your answer with evidence.
  Direct students to access the flashcard example as you introduce the vocabulary term *evidence*.
- What did you notice about the values for absolute magnitude and apparent magnitude after observing these stars? Support your claim with evidence.

> I noticed there are positive and negative numbers. For apparent magnitude, the lower the number (more negative), the brighter the star appears to us in the sky. The higher the number, the dimmer the star appears to us in the sky. For absolute magnitude, the brighter a star is, the lower the number. The dimmer the star is, the higher the number.

- Now that you know what these terms mean, make a claim about which star is actually the brightest and which is actually the dimmest. Support your claim with evidence.

> Betelgeuse is the brightest, and Sirius is the dimmest. I know Betelgeuse is the brightest, because its absolute magnitude is a negative number, and Sirius' absolute magnitude is a positive number.

- Do these stars appear that way from our view on Earth? Explain your thinking.
  Direct students to compare Betelgeuse and Sirius and discuss as a class.

> Sirius appears brighter to us, because of the five stars, it is the closest to Earth. However, it is actually very dim, with an absolute magnitude of 1.45. Betelgeuse is the brightest by absolute magnitude, but it is dimmer than Sirius in our sky because it is so far away. If both stars were the same distance from Earth, Betelgeuse would appear brighter.

21 Direct students to find Proxima Centauri in Star Chart. Lead a discussion about the brightness of this star.

- How would you describe the brightness of this star?
- What is its apparent magnitude? Absolute magnitude?
- Why do you think Proxima Centauri is so dim if it is 4.22 light-years away?

> **Note**: Proxima Centauri is the closest star to Earth beyond our solar system, yet it is dim with an apparent magnitude of 11.01. Proxima Centauri is a low-mass, low-luminosity, M-class dwarf star with an absolute magnitude of 15.45. It is about one-seventh the size of our Sun.

22 Guide students to answer the Conclusion Questions. Lead a discussion for students to share their thoughts.

## Conclusion Questions Answer Key

> **Note**: Conclusion Questions offer an opportunity for formative assessment. You may use them as a whole-class discussion or you may have students record ideas in their Launch Logs.

1 How is the Sun like other stars in the universe? Explain your thinking with evidence from the activity.

Student responses should demonstrate an understanding of stars. Responses might include:
Like other stars, the Sun is a large sphere of burning gases. It also emits light that we can see, just like other stars.

2 How is the Sun different from other stars? Explain your thinking with evidence from the activity.

Student responses should demonstrate an understanding of stars. Responses might include:
The Sun is a yellow dwarf star; not all stars are yellow dwarfs. There are stars that are much bigger and brighter than the Sun, and there are stars that are smaller and dimmer as well. The Sun is the only star in our solar system.

3 You look into the night sky and see two stars—one that is dim and one that is bright. Use what you have learned about stars to explain one reason why they appear this way to you.

Student responses should demonstrate an understanding of stars. Responses might include:
There are different reasons a star might appear bright or dim in the night sky. A star might appear bright or dim due to its distance from Earth. A star might appear very bright in our sky because it is close to Earth.
The Sun appears brightest in our sky because it is the closest star to Earth.

Also, a star might appear bright or dim because of its size. Stars come in different sizes. Some are small and some are large. Proxima Centauri appears very dim in the sky because it is a small star.

Activity 2

# Shadows

Teacher Resources

View Student Course

## EQUIPMENT

The list below is based on a class of 30 students.

| Included in the Equipment Kit | Not Included in Equipment Kit | Device Applications |
|---|---|---|
| • Model tree and shrub kit<br>• Card stock<br>• Flashlights (15)<br>• Measuring tapes (9)<br>• Compass<br>• Modeling clay | • PLTW Launch Logs (1 per student)<br>• Digital devices<br>• Pencils or colored pencils for sketching<br>• Grid chart paper (1 piece)<br>• Markers<br>• Resealable plastic bag | • Inkling<br>• Compass<br>• SmartCompass<br>• Camera<br>• ShowMe Interactive Whiteboard |

## ESSENTIAL QUESTIONS

EQ

EQ1 What is Earth's place in the universe?
EQ2 How do the predictable patterns of Earth impact our lives?
EQ3 How can a step-by-step process help you design or improve a solution to a problem?

## LEARNING OBJECTIVES

LO

LO1.2 Use scientific reasoning to ask questions, make observations, and investigate ideas to acquire knowledge and solve problems.
LO3 Identify the observable patterns that occur related to Earth.
LO4 Apply mathematical thinking to solve problems.
LO5 Collaborate effectively on a diverse and multidisciplinary team.
LO6 Communicate effectively for specific purposes and settings.
LO7 Practice ethical behavior in all settings.

## KNOWLEDGE AND SKILLS

KS

KS1.2.1 Ask and identify questions to gain knowledge or solve problems.
KS1.2.2 Make observations to draw conclusions of phenomena.
KS1.2.3 Analyze data to look for patterns or to test whether data are consistent with an initial prediction.
KS3.1 Develop an understanding of shadows and why they change throughout the day.
KS3.2 Explain the observable phenomena of day and night, daily changes in the direction and length of shadows, and different positions of the Sun, Moon, and stars at different times of the day, month, and year.
KS3.3 Explain how Earth rotates on an axis.
KS4.1 Make sense of problems and persevere in solving them. [CCSS.MATH.PRACTICE.MP1]
KS4.2 Reason abstractly and quantitatively. [CCSS.MATH.PRACTICE.MP2]
KS4.3 Construct viable arguments and critique the reasoning of others. [CCSS.MATH.PRACTICE.MP3]
KS4.4 Model with mathematics. [CCSS.MATH.PRACTICE.MP4]
KS4.5 Attend to precision. [CCSS.MATH.PRACTICE.MP6]
KS4.6 Represent data in graphical displays to reveal patterns.
KS4.7 Organize and present collected data visually to highlight relationships and support a claim. [CSTA 1B-DA-06]
KS4.8 Use data to highlight or propose cause-and-effect relationships, predict outcomes, or communicate an idea. [CSTA 1B-DA-07]
KS5.1 Generate ideas as a team.
KS5.2 Value the contributions of each team member.
KS5.3 Demonstrate collaboration through effective communication.
KS6.1 Document work in an organized notebook.
KS6.2 Explain findings and justify evidence-based conclusions with others.
KS6.3 Present data and information accurately and effectively.
KS6.4 Critique the explanations or solutions proposed by other students by citing evidence about the natural and designed world(s).
KS7.1 Engage in and maintain positive interactions and relationships with other children and adults.

## Preparation

### Part 1. Shadow Exploration

1. If students require additional knowledge about shadows, use the resources in the Light: Observing the Sun, Moon, and Stars module for additional support.
2. In Part 1, students work in small groups to explore shadows. Before you begin the activity, plan how you will group students and distribute materials. Each group needs:
   - Three or four trees from the tree and shrub kit
   - Three or four shrubs from the tree and shrub kit
   - Modeling clay to secure the trees and shrubs
   - One flashlight
   - One piece of card stock
3. Before you begin Activity 2, use a compass to determine how your classroom is oriented to the cardinal directions (north, south, east, and west). To use a compass:
   - Hold the compass facing up, flat in your hand
   - Keep your hand still, turn your body until the arrow points north

### Part 2. Observing and Predicting Shadows

**Note**: The complete Scientific Inquiry Process will span two or more days. The Predict and Observe steps should take place over two days, three times per day, for students to observe their shadows.

1. In this activity, students use the Scientific Inquiry Process. This process is similar to the design process, but there are distinct differences. The Scientific Inquiry Process:
   - Provides exposure and experience for students to think and work scientifically.
   - Allows students to collect data and answer testable questions.
   - Helps students learn how to approach a testable question and set up an experiment to collect the necessary data.

   **Testable Questions**
   In the Ask step of the Scientific Inquiry Process, students brainstorm testable questions about a topic. A testable question is one that can be answered by designing and conducting an experiment or investigation. It needs to be specific enough where you only test one variable at a time to draw conclusions. The answers to a testable question can be observed and measured. Examples of testable questions include:
   - What happens to mass when two substances are mixed together?
   - What happens when you mix red, blue, and green colored light in different combinations?
   - Do plants need sunlight to grow?
   - What affects the brightness of a star in our night sky?
2. Before you begin Part 2, plan how you will facilitate the shadow observations, including working with other teachers and administrators to schedule observations outside of normal class time. Additional considerations:
   - Schedule three times spread throughout the school day that you can take students outdoors two days. For example, you might take students outside first thing in the morning, before lunch, and before dismissal. The times should be consistent between the two days.
   - Locate the best outdoor location to take students. Students will need to observe their shadows, so the location should have access to sun and minimal interference from other structures.
   - Consider the upcoming weather, as sunny days are needed for this activity. Even a partly cloudy day can make seeing shadows difficult if the Sun is behind a cloud.

**Time**: 120 Minutes

## Introduction

In this activity, students study *shadows*, inside and outside the classroom, to learn about Earth's *rotation*. Students model how the *Sun's* light causes shadows. Then they follow the *scientific inquiry process* to investigate how their shadow changes over the course of the day. By graphing and analyzing their data, students recognize that Earth's rotation causes predictable and observable *patterns*.

| | |
|---|---|
| cardinal directions | The directions of north, east, south, and west. |
| evidence | Information that explains or supports a claim. |
| observe | To watch and listen to something carefully. |
| pattern | Something that is repeated over and over. |
| rotation | The act of turning around on a fixed point. |
| scientific inquiry process | A process that scientists use to explore observations and answer questions. |
| scientist | A person who asks questions, makes observations, and investigates ideas to acquire knowledge and/or solve problems. |
| shadow | The dark area formed when an object blocks rays of light. |
| Sun | The star at the center of our solar system. |

### Possible Student Misconceptions

- **Earth does not move**. Earth is constantly moving around the Sun and rotating on its axis. Earth's orbit and rotation are due to the pull of gravity from the Sun and the huge collisions with other chunks of rock as the planet formed.
- **Rotation is the same as orbit**. Rotation is often mistakenly used to describe the motion of Earth orbiting the Sun. Earth rotates once on its axis each day. Earth orbits the Sun once a year.
- **Shadows are always the same size throughout the day**. The position of the Sun affects the size of a shadow. When the Sun is low in the sky, an object will block more of the light, creating a larger shadow. When the Sun is directly above, less light is blocked, creating a smaller shadow.
- **The Sun moves across the sky**. Earth's rotation causes the Sun to appear to move across the sky. Our day occurs when the rotation of Earth turns us toward the Sun. Our night occurs when the rotation of Earth turns us away from the Sun.

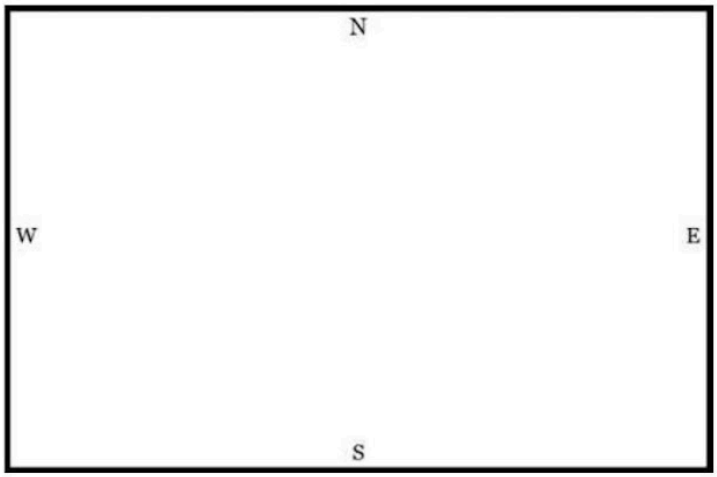
## Procedure

### Part 1. Shadow Exploration

1. Direct students to access Activity 2 in the student course and have them read the Introduction.
2. Have students prepare their PLTW Launch Logs for Activity 2.
3. Lead a discussion about shadows to activate prior knowledge.

   - What is a shadow?
     Direct students to access the flashcard example as you introduce the vocabulary term *shadow*.
   - When do you see your shadow?
     Direct students to access the flashcard example as you review the vocabulary term *Sun*.
   - Where does a shadow come from? Explain your thinking.

4. Provide small groups with the following materials:
   - Three or four trees from the tree and shrub kit
   - Three or four shrubs from the tree and shrub kit
   - Modeling clay to secure the trees and shrubs
   - One flashlight
   - One piece of card stock
5. Introduce the shadow simulation. Explain to the students that in this simulation they will explore how shadows are cast by the trees when a flashlight shines on them. In this model, the flashlight represents the Sun. Students will make the light source move over the scene.
   In reality, it is the rotation of Earth that causes the Sun to appear to move across the sky. The students are simulating the appearance of the Sun in the sky as the Earth rotates. Explain that as Earth rotates, the Sun appears to move from east to west, but in reality, the Sun does not move.
6. Direct students to access the flashcard examples as you introduce the vocabulary terms *rotation* and *cardinal directions*.
7. Have students label their card stock: N, S, W, and E.




8. Guide students to orient themselves North using a physical compass or the compass app on their digital device. Direct students to align the labeled card stock with the cardinal directions and place on a desk.

9. Have students set up the trees and shrubs on the card stock in a varied way, as they might see in nature.

10. Demonstrate how to shine the flashlight on the trees and shrubs. Move it in a slow arc from east to west—the directions the Sun appears to rise and set. While you move the flashlight, model:
    - The position of the Sun at sunrise (low in the eastern sky)
    - The position of the Sun at noon (directly overhead)
    - The position of the Sun at sunset (low in the western sky)

11. Have the students shine their flashlights on the trees and shrubs. As they move the flashlight, students should observe the shadows of the trees and shrubs and notice how they change from sunrise to noon to sunset. Direct students to access the flashcard example as you introduce the vocabulary term *observe*.

12. Guide students to draw their observations in their Launch Logs for sunrise, noon, and sunset. The drawings should include the Sun, trees, shrubs, and shadows.

13. Lead a discussion about the simulation.

    - How did the shadows change?
    - What caused the change?
    - What patterns did you observe?

    Direct students to access the flashcard example as you introduce the vocabulary term *pattern*.

**Note**: At the end of Part 1, put the modeling clay in a resealable plastic bag. This modeling clay will be used in Activity 3 and the problem.

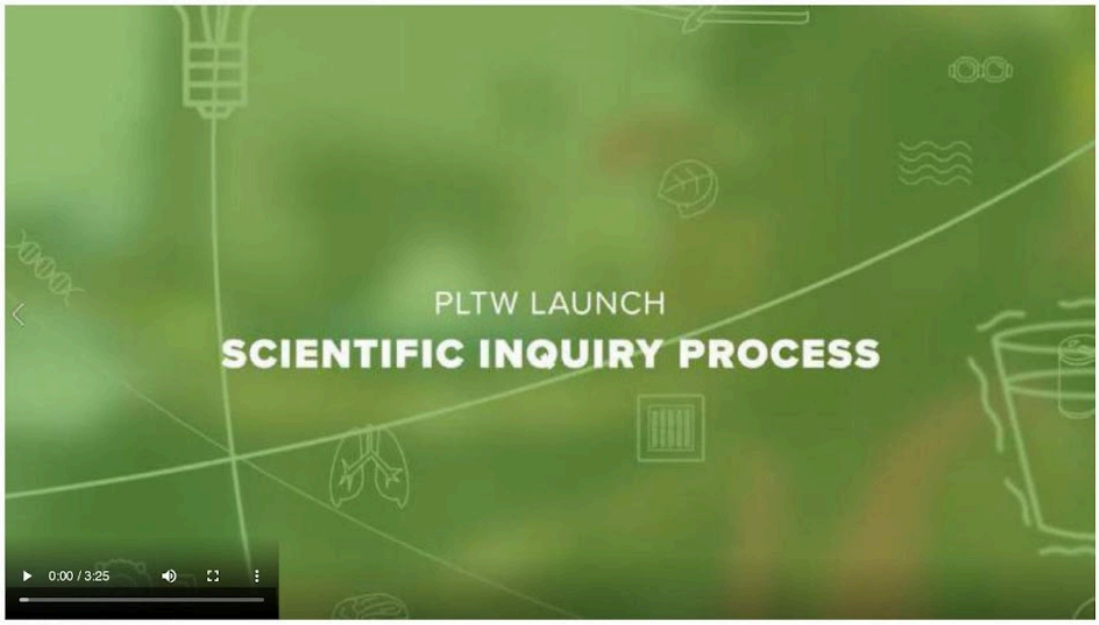
## Part 2. Observing and Predicting Shadows

**Note**: The procedure for Part 2 cannot be completed in one day. This investigation asks students to make predictions and observations outdoors three separate times over the course of two days. Consider working with other teachers and administration to allow students to conduct their observations outside of their normally scheduled class time, if necessary.

14. Explore students' ideas about the work of scientists. Lead them to understand that scientists are people who ask questions, make observations, and investigate ideas, to acquire knowledge and/or solve problems. Tell students that they are now going to act as scientists to learn more about shadows.

    - What do you think scientists do?
    - Why do you think this?

15. Guide students to view the Scientific Inquiry Process video as an introduction to scientists and the scientific inquiry process.




Scientific Inquiry Process video

16 Lead a discussion about what students learned from the Scientific Inquiry Process video.

- Why do scientists use the scientific inquiry process?
  Direct students to access the flashcard example as you review the vocabulary term *scientific inquiry process*.
- How do you think the scientific inquiry process helps scientists in their work?
- Why is it important to ask questions as you work through the scientific inquiry process? Why do you think that?
- What makes a question testable? What are some testable questions you have investigated in the past?

17 **Ask**: Direct students to work with a small group to brainstorm testable questions about how Earth's rotation affects the shadows we see outside.

- Allow time for each group to share some of their questions with the class. Ask students to share ideas for how you would test questions like those they have presented.
- Present the testable question for this investigation: How does Earth's rotation affect the shadows we see? Have students record the testable question in their Launch Logs.

18 **Predict**: Guide students to make a prediction to answer the testable question for this investigation.

- Direct students to record their predictions in their Launch Logs about how Earth's rotation affects the shadows we see.
- Remind students that their predictions should be based on their past experiences and prior knowledge.
- Lead a discussion about the testable question for this investigation.

  - How does Earth's rotation affect the shadows we see? Why do you think this?
  - How do you think we could test this question?

19 Have students create a chart in their Launch Logs to record the shadow data. Optional: Direct students to add space to their chart to sketch their shadow during each observation or take a photograph using their digital device.

| | Morning Observation | | Midday Observation | | Afternoon Observation | |
|---|---|---|---|---|---|---|
| | Day 1 | Day 2 | Day 1 | Day 2 | Day 1 | Day 2 |
| Time of observation | | | | | | |
| Prediction of shadow length in inches | | | | | | |
| Actual shadow length in inches | | | | | | |

20 **Predict Day 1**

- Explain that students will go outside three times a day for two days to observe and measure their shadows.
- Before making the first observation outside, direct students to predict how long their shadow will be in inches at that time of day.
- Have students record their predictions in the data collection chart in their Launch Logs.

> **Note**: Explain to students that they will also make predictions before making the next two observations. They can use the data from the first observation to help them make a prediction for the next time of day.

21 **Investigate and Observe Day 1**: Guide students to test their predictions and make observations by carrying out an investigation.

- Distribute a measuring tape to each group.
- Take the students outside and have the groups spread out so they do not overlap others' shadows.
- Guide one student in each group to stand alone and cast a shadow. Have the group observe the shape and length of the shadow.
- Have another student measure the shadow from the shoes of the student casting the shadow to the farthest point of the shadow.
- The student who cast the shadow records the length of their shadow in their Launch Log.
- Optional: Have students sketch their shadow during the observation or take a photograph using their digital device.
- Switch roles and perform this procedure for each student in the group.

> **Note**: Remind students to make predictions before they make each observation.

22 Lead a discussion with students about their predictions and observations from Day 1.

> **Note**: This discussion can occur at the end of Day 1 or the beginning of Day 2.

- Did your predictions match the data you collected? Were your predictions close to or far from the actual measurements?
- How did the length of your shadow change throughout the day?
- Do you expect the length of your shadow to be exactly the same on Day 2 as it was on Day 1? Why or why not? Support your answer with evidence.

  Direct students to access the flashcard example as you review the vocabulary term *evidence*.

23 **Predict Day 2**: Direct students to make their new predictions for Day 2 based on their data and observations from Day 1.

24 **Investigate and Observe Day 2**: Have students repeat the investigation from Day 1.

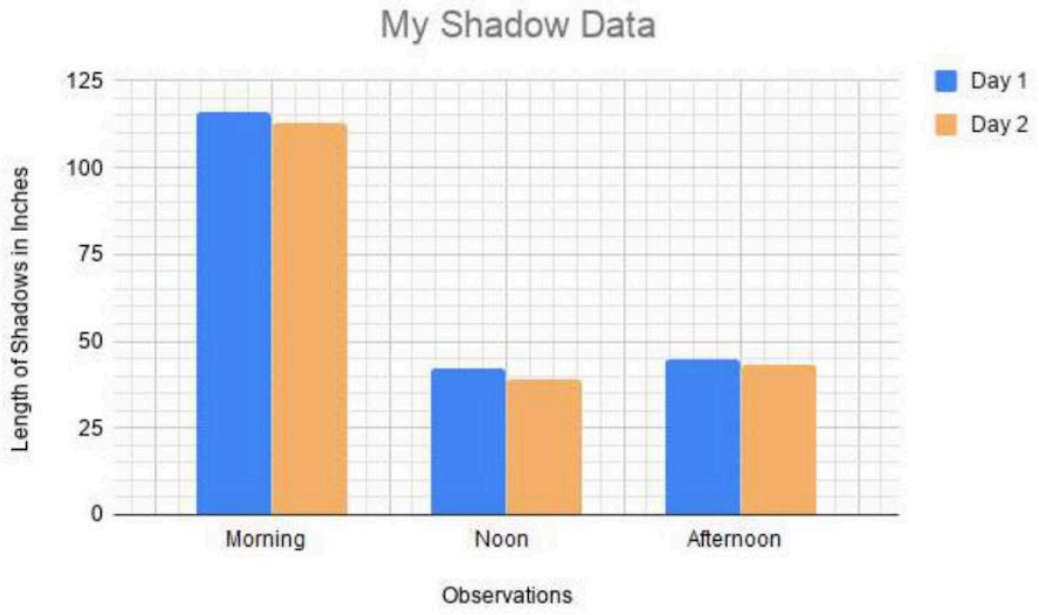
25 Lead a discussion with students about their observations and predictions from Day 2.

- Were your predictions more accurate today? Why do you think this?
- How do the lengths of your shadows compare from Day 1 to Day 2? Are they similar or different? Why do you think that is?

## Part 3. Graphing and Analyzing Data

26 **Observe**: Model how to create a double bar graph to display the data from the student observations. Use a piece of grid chart paper or ShowMe Interactive Whiteboard to create the graph.

- Create a title
- Draw x- and y-axes on a grid
- Label the x-axis, "Observations"
- Label the y-axis, "Length of Shadows in Inches"
- Use the data from the observations to create a double bar graph




My Shadow Data graph

27 Direct students to graph their data from their shadow observations in their Launch Logs. Students should only record the lengths of their shadows in this graph, not their predictions.

28 Guide students to analyze their data and compare it with others in a small group. Have them look for patterns or inconsistencies.

29 **Explain**: Lead a discussion with students about their data and group conversations.

- What pattern(s) did you find in your data and the data of others?
- Why do you think this pattern is consistent from person to person?

> Even though students vary in height, the pattern of how their shadows change throughout the day will be the same. Earth's rotation causes the Sun to appear in different positions in the sky, and if anyone goes outside, they will cause a shadow by blocking the Sun. If the Sun is directly overhead, your body blocks light directed at the top of your head and causes a shadow directly underneath your body. If the Sun is lower in the sky, your body blocks light directed at your entire body and causes a long shadow.

- What do you think the length of your shadow will be at 7:00 p.m.? Why do you think that?
- How do you think Earth's rotation affects our shadows?

> Earth's rotation causes the Sun to appear to move across our sky from east to west. The Sun causes shadows to appear short or long, depending on where it is in the sky.

30 Guide students to answer the Conclusion Questions. Lead a discussion for students to share their thoughts.

## Conclusion Questions Answer Key

1 Why do shadows change length throughout the day?

> Student responses should demonstrate an understanding of shadow and Earth's rotation. Responses might include:
> When Earth rotates, the Sun appears to move through the sky. Shadows change length because the Sun has different positions in our sky and this causes light to hit Earth from different directions and angles.

2 What patterns do you observe due to Earth's rotation?

Student responses should demonstrate an understanding of the patterns and Earth's rotation. Responses might include:
Earth's rotation is responsible for several patterns. First, Earth's rotation is responsible for our days and nights. It takes Earth 24 hours to rotate. During this time, we experience day and night. Also, Earth's rotation makes our Sun appear to move across the sky from east to west.

3 Why is your morning shadow longer than your midday shadow? Use evidence from this activity to support your answer.

Student responses should demonstrate an understanding of the shadows. Responses might include:
My morning shadow is longer than my midday shadow because of the location of the Sun in the sky. In the morning, the Sun is in the eastern sky. The light strikes my body from the top of my head down to my feet. My body blocks the light which creates a long shadow. My midday shadow is shorter because the Sun is directly overhead. My head and shoulders are the main part of my body blocking the light. This creates a smaller shadow.

Activity 3

# Predictable Patterns

Teacher Resources

View Student Course

## EQUIPMENT

The list below is based on a class of 30 students.

| Included in Equipment Kit | Not Included in Equipment Kit | Device Applications |
|---|---|---|
| • *The Next Time You See a Sunset* by Emily Morgan (2)<br>• *The Moon Book* by Gail Gibbons (2)<br>• Blue modeling clay<br>• Gray modeling clay<br>• Wooden dowels<br>• Rounded toothpicks<br>• Flashlights (4) | • PLTW Launch Logs (1 per student)<br>• Digital devices<br>• Pencils or colored pencils for sketching<br>• Resealable plastic bags (2) | • Inkling<br>• Star Chart<br>• What Causes the Seasons? by NASA Space Place |

## ESSENTIAL QUESTIONS

EQ

EQ1 What is Earth's place in the universe?

EQ2 How do the predictable patterns of Earth impact our lives?

EQ3 How can a step-by-step process help you design or improve a solution to a problem?

## LEARNING OBJECTIVES

LO

LO1.2 Use scientific reasoning to ask questions, make observations, and investigate ideas to acquire knowledge and solve problems.

LO2.1 Compare and contrast the Sun to other stars.

LO2.2 Understand the universe includes all the natural bodies in space.

LO3 Identify the observable patterns that occur related to Earth.

LO4 Apply mathematical thinking to solve problems.

LO5 Collaborate effectively on a diverse and multidisciplinary team.

LO6 Communicate effectively for specific purposes and settings.

LO7 Practice ethical behavior in all settings.

## KNOWLEDGE AND SKILLS

KS

| | |
|---|---|
| KS1.2.1 | Ask and identify questions to gain knowledge or solve problems. |
| KS1.2.2 | Make observations to draw conclusions of phenomena. |
| KS1.2.3 | Analyze data to look for patterns or to test whether data are consistent with an initial prediction. |
| KS2.1.1 | Identify what a star is. |
| KS2.1.2 | Understand that the Sun is a star. |
| KS2.1.3 | Understand that some stars appear brighter due to their relative distance from Earth. |
| KS2.1.4 | Develop a basic understanding of apparent magnitude and absolute magnitude of stars. |
| KS2.2.1 | Develop a basic understanding of Earth's place in the universe. |
| KS3.2 | Explain the observable phenomena of day and night, daily changes in the direction and length of shadows, and different positions of the Sun, Moon, and stars at different times of the day, month, and year. |
| KS3.3 | Explain how Earth rotates on an axis. |
| KS3.4 | Explain how Earth orbits the Sun. |
| KS3.5 | Explain how the Moon orbits Earth. |
| KS4.1 | Make sense of problems and persevere in solving them. [CCSS.MATH.PRACTICE.MP1] |
| KS4.2 | Reason abstractly and quantitatively. [CCSS.MATH.PRACTICE.MP2] |
| KS4.3 | Construct viable arguments and critique the reasoning of others. [CCSS.MATH.PRACTICE.MP3] |
| KS4.4 | Model with mathematics. [CCSS.MATH.PRACTICE.MP4] |
| KS4.5 | Attend to precision. [CCSS.MATH.PRACTICE.MP6] |
| KS4.7 | Organize and present collected data visually to highlight relationships and support a claim. [CSTA 1B-DA-06] |
| KS4.8 | Use data to highlight or propose cause-and-effect relationships, predict outcomes, or communicate an idea. [CSTA 1B-DA-07] |
| KS5.1 | Generate ideas as a team. |
| KS5.2 | Value the contributions of each team member. |
| KS5.3 | Demonstrate collaboration through effective communication. |
| KS6.1 | Document work in an organized notebook. |
| KS6.2 | Explain findings and justify evidence-based conclusions with others. |
| KS6.3 | Present data and information accurately and effectively. |
| KS6.4 | Critique the explanations or solutions proposed by other students by citing evidence about the natural and designed world(s). |
| KS7.1 | Engage in and maintain positive interactions and relationships with other children and adults. |

# Preparation

## Professional Development

Before you facilitate Activity 3, access the **Patterns in the Universe Module-specific PD Resources** to review Building Your Understanding: Patterns of the Moon.

## Activity 3

1. Review the Procedure to facilitate the scientific inquiry process with students.
2. If needed, review the Scientific Inquiry Process video found in Activity 2.

> **Note**: The investigations in PLTW Launch are designed as a way for small groups to explore the learning activities independently.
>
> The number of investigations you need for a class will vary depending on class size. The directions are written for a class of 30 students. If your class is larger or smaller, adjust your investigations accordingly. Students will work in groups of two to four.
>
> Before you start Activity 3, determine the best way to implement and set up the investigations for your students. You may decide that your students need additional background information or require an adult's assistance for a particular investigation. As you prepare the investigations, consider, and plan for, any additional support your students need.
>
> Guided exploration allows students to build knowledge that contributes to understanding Earth's place in the universe and the patterns we experience due to planetary rotation and orbit. It is important that each student engage in every investigation to acquire the skills necessary for completing the Problem.

3. Before you begin Activity 3, gather items needed for the investigations. The notes for each investigation prep include the specific materials you need.

**Investigation 1: Constellations**

- Review the Procedure for Investigation 1 to become familiar with the content students will explore.
- Set up this investigation to allow students to explore the relationship between a star's brightness and its distance from Earth using the Star Chart app.
- Purpose: Students observe how stars appear to us on Earth. A measurement of how bright a star appears from Earth is called its apparent magnitude. Two main factors influence how a star appears to us—the star's actual brightness, or absolute magnitude, and its distance from Earth.
- Materials: Digital devices with the Star Chart app and Launch Logs

> **Note**: This investigation allows students to build upon their learning from Activity 1. In small groups, students will use the Star Chart app to explore the relationship between a star's brightness and its distance from Earth. Students will be able to apply the knowledge they gained in Activity 1 as they investigate further in this activity.

**Investigation 2: Day and Night**

- To become familiar with the content students will explore, review the Procedure for Investigation 2.
- Set up this investigation to allow students to explore the relationship between Earth's rotation and its day and night cycle; use modeling clay and a flashlight.
- Select a location for this investigation that does not have direct sunlight or interior lighting. This may be a dark room, section of the room with no lights, or even inside a box or under a desk. The amount of direct sunlight or interior lighting will impact how well the students are able to model and see the necessary light and dark patterns of the day and night cycle.
- This investigation requires students to create a clay model. You may wish to prepare a sample model of Earth to help guide students as they create their own. Alternatively, you may choose to make a model in advance and provide it for students to use during the investigation.
- Read the book *The Next Time You See a Sunset* to become familiar with its contents.
- Purpose: Students observe what causes the day and night cycle. It takes Earth 24 hours to rotate on its axis. This rotation causes the day and night cycle.
- Materials: Blue modeling clay, wooden dowels (2), flashlights (2), *The Next Time You See a Sunset*, and Launch Logs.

> **Note**: The equipment kit contains two copies of *The Next Time You See a Sunset*, in case you need to duplicate this investigation.

**Investigation 3: Moon Phases**

- To become familiar with the content students will explore, review the Procedure for Investigation 3.
- Set up this investigation to allow students to explore the cause of the Moon's phases using modeling clay and a flashlight.
- Select a location for this investigation that does not have direct sunlight or interior lighting. This may be a dark room, section of the room with no lights, or even inside a box or under a desk. The amount of direct sunlight or interior lighting will impact how well the students are able to model and see the necessary light and dark patterns of the moon phases.
- This investigation requires students to create clay models. You may wish to prepare sample models of Earth and the Moon for the investigation to help guide students as they create their own. Alternatively, you may choose to make the models in advance and provide them for students to use during the investigation.
- Read the book *The Moon Book* to become familiar with its contents.

- To become familiar with its contents, review the Our World: Moon Phases video.
- Purpose: Students observe what causes the Moon's phases. The phases of the Moon are caused by the Earth-Moon-Sun system. The Moon does not emit its own light. It reflects light from the Sun. As the Moon orbits Earth, different parts of the Moon are lit by the Sun. This causes the phases.
- Materials: Blue modeling clay, gray modeling clay, wooden dowels (2), rounded toothpicks (2), flashlights (2), *The Moon Book*, digital devices, and Launch Logs.

> **Note**: The equipment kit contains two copies of *The Moon Book*, in case you need to duplicate the investigation.

**Investigation 4: Earth's Orbit Around the Sun**

- To become familiar with the content students will explore, review the Procedure for Investigation 4.
- Set up this investigation to allow students to explore what causes the seasons.
- Read **What Causes the Seasons?** by NASA Space Place to become familiar with its contents.
- To become familiar with its contents, review the Our World: Sun's Position video.
- Purpose: Students observe what causes the seasons. The seasons are caused by Earth's tilt on its axis. This tilt affects how the Sun's rays strike Earth. The hemisphere that receives direct rays experiences summer, and the hemisphere that receives indirect rays experiences winter.
- Materials: Blue modeling clay, wooden dowels (2), digital devices, and Launch Logs.

4. Duplicate each investigation as needed to accommodate your class size.

**Time**: 110 Minutes

## Introduction

In our daily lives, there are so many things we can predict with certainty. We know that the *Sun* will rise in the morning and set in the evening. We know one day lasts 24 hours, and there are seven days in a week.

In this activity, students explore the *patterns* of our planet that make this kind of predictability possible. Students use the *scientific inquiry process* to learn more about Earth's place in the *solar system*. As they model Earth's *rotation*, Earth's *orbit*, and the Moon's orbit, they discover the predictable patterns we experience on Earth.

| | |
|---|---|
| absolute magnitude | A measurement of how bright stars would appear if all stars were the same distance from Earth; also known as luminosity. |
| apparent magnitude | A measurement of how bright a star appears from Earth. |
| constellation | A group of stars that appears to form an image and has been given a name. |
| gravity | A force that pulls two objects toward one another. |
| model | A copy of an object that can be smaller or larger than the original. |
| moon | A large, natural body that orbits a planet. |
| orbit (noun) | The curved path of an object around a star, planet, or moon. |
| orbit (verb) | To move around a larger object in space. |
| pattern | Something that is repeated over and over. |
| rotation | The act of turning around on a fixed point. |
| scientific inquiry process | A process that scientists use to explore observations and answer questions. |
| solar system | The system of planets, including Earth, moons, and other bodies that orbit the Sun. |
| star | A huge sphere of very hot, glowing gas that produces its own light. |
| Sun | The star at the center of our solar system. |

## Possible Student Misconceptions

- **Rotation is the same as orbit**. Rotation is often mistakenly used to describe the motion of Earth orbiting the Sun. Earth rotates once on its axis each day. Earth orbits the Sun once a year.
- **Earth is the center of the solar system, with the Sun and planets orbiting around it. This is why day and night occur**. The Sun is the center of the solar system, and Earth and the other planets orbit around it. The Sun is so large, it has a strong gravitational force that pulls the planets into orbit. Day and night occur due to Earth's rotation, not its orbit around the Sun.
- **At night the Sun changes into the Moon**. Earth's moon is a separate object in our sky from the Sun. It reflects light from the Sun back toward Earth. Sometimes, you can see the Moon in the daytime sky with the Sun.
- **The Moon disappears during the day**. The Moon orbits Earth like Earth orbits around the Sun. We can see the Moon as its orbit brings it into our view, giving us a moonrise and moonset. The Moon's orbit takes it around Earth about once each month, while Earth rotates much faster. As a result, the Moon appears to move very slowly across the night sky each night. Sometimes our hemisphere of Earth turns to face the Moon during the day, and we cannot see it because the light from the Sun is brighter than the light being reflected from the Moon. Sometimes, the Moon is in the perfect spot, and it reflects enough light to be visible in the daytime sky.
- **The Moon rotates, and we can see the different areas of the moon throughout the month**. The Moon does spin on its axis, completing a rotation once every 27.3 days. However, it also takes the Moon 27.3 days to orbit Earth. Since the rotation and orbit match, only one side of the Moon is visible to us on Earth. The other half of the Moon, sometimes called the far side or dark side (although it also receives light from the Sun), is never visible from Earth.
- **Earth's shadow is responsible for the different phases of the Moon**. It is uncommon for Earth's shadow to fall on the Moon; when it does, it is called a lunar eclipse. Instead, when we see the Moon lit up, we are seeing the Sun's light causing daytime on the surface of the Moon that faces Earth. As the Moon orbits Earth, we see different parts of the Moon's night and day. When we see a full moon, we are seeing only the part of the Moon experiencing daytime. When we see a new moon, or no moon, we see only the part experiencing nighttime. When we see some light and some dark, as seen in most phases, we see parts experiencing daytime and parts experiencing nighttime.
- **The Sun, Earth, and Moon are all similar sizes**. The Sun is over a million times bigger than Earth. The Moon is four times smaller than Earth.

## Procedure

1. Direct students to access Activity 3 in the student course and have them read the Introduction.
2. Have students prepare their PLTW Launch Logs for Activity 3.
3. Lead a discussion to review Activities 1 and 2.

- Some stars are bright, and some stars are dim. What affects a star's brightness?
  Direct students to access the flashcard examples as you review the vocabulary terms *star, apparent magnitude,* and *absolute magnitude*.
- Why is the Sun the brightest star in the sky?
  Direct students to access the flashcard examples as you review the vocabulary term *Sun*.
- What causes the stars' apparent movement in the sky?
  Direct students to access the flashcard examples as you review the vocabulary terms *rotation* and *orbit*.

> **Note**: There are two definitions of the vocabulary term *orbit*. One is the noun form, and one is the verb form. Both definitions are used throughout the module.

- How do our shadows change throughout the day? What causes this change?

4. Explain to students that they will work in small groups to investigate how the predictable patterns of Earth impact our lives. Direct students to access the flashcard examples as you review the vocabulary terms *pattern* and *scientific inquiry process*.
5. Introduce the following investigations to the students in detail. Be sure to present new tools or equipment, such as how to create an Earth and Moon model and how to hold the Earth model tilted on its axis. Direct the students to access the flashcard example to introduce the vocabulary term *model*. Remind students that, as they investigate different phenomena in space, they will use the same process as scientists. As such, it is important to support their claims with evidence. Direct the students to access the flashcard example to review the vocabulary term *evidence*.

- **Investigation 1: Constellations**
  Guide students to:
  - Ask: What affects the brightness of a star in our night sky?
  - Predict: Choose a constellation from the list below. Use the Star Chart app to view the constellation and identify its stars. Use only their eyes to predict which stars are closest to Earth based on their brightness. Constellation choices:
    - Phoenix (six stars)
    - Toucan (six stars)
    - Flying Fish (five stars)
    - Cassiopeia (five stars)
    - Crab (five stars)

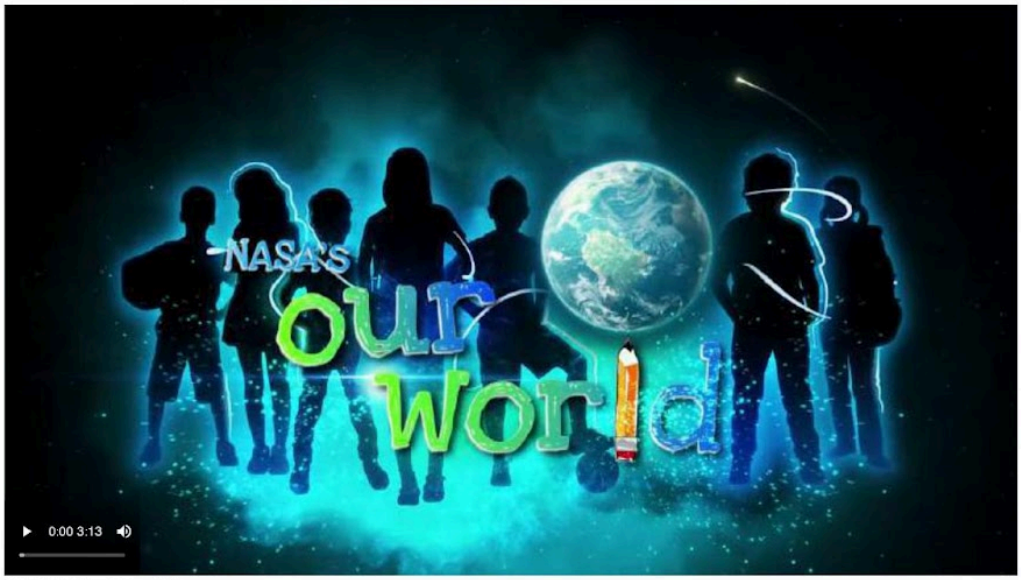
- Cepheus (five stars)
- Chameleon (five stars)
- Southern Crown (five stars)
- Lesser Lion (five stars)
- Lyre (five stars)

- Investigate: Use the Star Chart app to examine the details of each star in the constellation. Make a chart to rank the stars, closest to farthest, by their distance in light-years from Earth. Remind students that a light-year is a unit of distance equal to the distance that light travels in one Earth year, which is about six trillion miles. Then, add the apparent magnitude and absolute magnitude for each star.
- Observe: Compare the data to their predictions.
- Explain: Answer the original question in their Launch Logs and support their claim with evidence.

- **Investigation 2: Day and Night**

  Guide students to:
  - Ask: What causes Earth's day and night cycle?
  - Predict: Consider what they know about Earth's rotation and make a prediction about what causes Earth's day and night cycle.
  - Investigate: Read the book, *The Next Time You See a Sunset*.
  - Observe: With a partner, create Earth out of blue modeling clay. Place the model of Earth on a wooden dowel. Shine a flashlight at the model of Earth and rotate the model using the wooden dowel. Observe how different parts of Earth receive daylight while other parts receive no light.
  - Explain: Answer the original question in their Launch Logs and support their claim with evidence.
- **Investigation 3: Moon Phases**

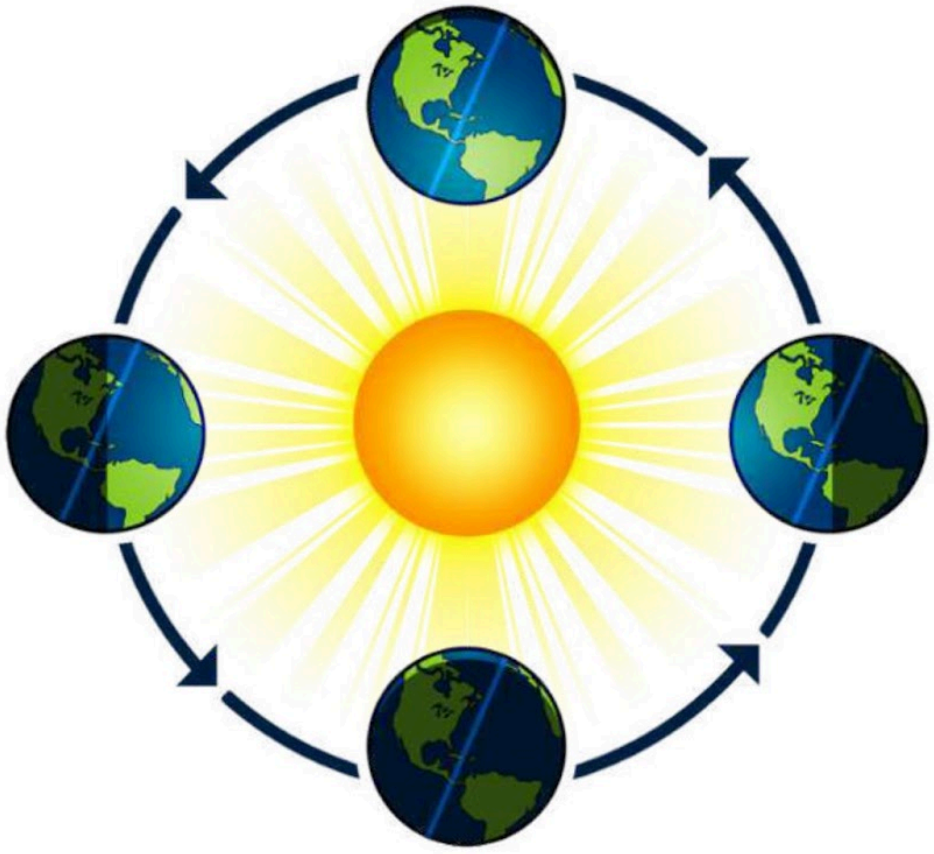
  Guide students to:
  - Ask: What causes the Moon's phases?
  - Predict: Consider what students know about the Moon and predict what causes the Moon's phases.
  - Investigate: Read the book, *The Moon Book*, from the beginning until the section titled, "Solar Eclipse."
  - Observe:
    - With a partner, create Earth out of blue modeling clay. Place the model of Earth on a wooden dowel. Create the Moon out of gray modeling clay and place it on a toothpick. Shine a flashlight at the model of Earth and the Moon. Model the orbit of the Moon around Earth. Observe the side of the Moon that is facing Earth and watch how its phases, the pattern of light and dark on its surface, change as it orbits around Earth.
    - To learn more about the phases of the moon, watch the Our World: Moon Phases video.




Our World: Moon Phases video

  - Explain: Answer the original question in their Launch Logs and support their claim with evidence.
  - Optional: If time permits, finish *The Moon Book*.
- **Investigation 4: Earth's Orbit Around the Sun**

  Guide students to:
  - Ask: What causes the seasons?
  - Predict: Consider what they know about Earth's tilt and make a prediction about what causes the seasons.
  - Investigate: Read **What Causes the Seasons?** by NASA Space Place.
  - Observe:
    - With a partner, create Earth out of blue modeling clay. Place the model of Earth on a wooden dowel; slide Earth on the wooden dowel so the dowel can be seen above and below Earth. Have one partner stand still to represent the Sun. Have the other partner model how Earth orbits the Sun while tilted on its axis.



Earth's Tilt

- To learn more about the Sun and Earth, watch the **Our World: Sun's Position** video.
  - Explain: Answer the original question in their Launch Logs and support their claim with evidence.

6. Guide students to rotate through the four investigations to explore different phenomena in space.
7. As students rotate through the investigations, ask questions and observe students as they create and act out the models. Correct student modeling when needed.

> **Note**: In the Day and Night and Moon Phases investigations, it is important that students create accurate models of the movement of the Earth, Sun, and/or Moon to make accurate observations and conclusions. Be prepared to check student models and demonstrate the correct movement of the Moon and Earth in relation to the Sun.

8. Lead students in a discussion of what they discovered through the investigations.

- Investigation 1: Constellations
  - What affects the brightness of a star in our night sky?
  - Can you simply observe the brightness of a star in the night sky and make a guess about its distance from Earth? Why or why not?
- Investigation 2: Day and Night
  - What causes Earth's day and night cycle? Explain your answer using what you observed in your investigation.
  - Describe the predictable pattern with Earth's day and night cycle.
- Investigation 3: Moon Phases
  - What causes the Moon's phases?
  - Is there a predictable pattern to the phases of the Moon? How do you know?
  - What role does Earth play in causing the phases of the Moon?
- Investigation 4: Earth's Orbit Around the Sun
  - What causes the seasons?
  - Describe the predictable pattern with Earth's seasons.

9 Guide students to answer the Conclusion Questions. Lead a discussion for students to share their thoughts.

**Note**: Place the modeling clay in resealable plastic bags at the end the activity. This modeling clay will be used in the problem.

## Conclusion Questions Answer Key

1 Over one 24-hour day, what predictable patterns of Earth can you observe? What causes the predictable patterns?

Student responses should demonstrate an understanding of the predictable patterns. Responses might include:
Within one day, I observe the sunrise and sunset. This is a predictable pattern because the sunrise and sunset occur every day due to Earth's rotation.
Another predictable pattern is how the Sun appears to move across the sky. The Sun appears to move from the East to the West. This predictable pattern is also caused by Earth's rotation. Finally, the phases of the Moon are predictable. The phases are a repeated pattern caused by light from the Sun reflecting off the Moon toward Earth. The Moon's orbit of the Earth puts the Moon in different places each day. Sometimes the Moon gets more light or less light from the Sun, which causes the phases.

2 One of Earth's predictable patterns is its orbit around the Sun. It takes Earth 365 days to orbit the Sun. Do you think the other planets in our solar system have a 365-day year? Explain your reasoning.

Student responses should demonstrate an understanding of the predictable patterns in our solar system. Responses might include:
The other planets in the solar system do not have a 365-day year like Earth. Some planets are closer to the Sun, so their orbits are smaller than Earth's. This means it does not take them as long to complete an orbit, so they have a shorter year. Some planets are further away from the Sun, so their orbits are larger than Earth's. This means that they have much further to travel in their orbit than Earth, so their year is longer than ours.

3 How would your life be different if Earth did not have predictable patterns?

Student responses will vary.

Project

# Changes in the Sky

Teacher Resources

View Student Course

## EQUIPMENT

The list below is based on a class of 30 students.

| Included in Equipment Kit | Not Included in Equipment Kit | Device Applications |
|---|---|---|
| • Compass | • PLTW Launch Logs (1 per student)<br>• Digital devices<br>• Pencils or colored pencils for sketching<br>• Sticky notes | • Inkling<br>• Compass<br>• SmartCompass<br>• Stellarium Web |

## ESSENTIAL QUESTIONS

EQ

EQ1 What is Earth's place in the universe?
EQ2 How do the predictable patterns of Earth impact our lives?
EQ3 How can a step-by-step process help you design or improve a solution to a problem?

## LEARNING OBJECTIVES

LO

LO1.2 Use scientific reasoning to ask questions, make observations, and investigate ideas to acquire knowledge and solve problems.
LO2.1 Compare and contrast the Sun to other stars.
LO2.2 Understand the universe includes all the natural bodies in space.
LO3 Identify the observable patterns that occur related to Earth.
LO4 Apply mathematical thinking to solve problems.
LO5 Collaborate effectively on a diverse and multidisciplinary team.
LO6 Communicate effectively for specific purposes and settings.
LO7 Practice ethical behavior in all settings.

## KNOWLEDGE AND SKILLS

KS

| | |
|---|---|
| KS1.2.1 | Ask and identify questions to gain knowledge or solve problems. |
| KS1.2.2 | Make observations to draw conclusions of phenomena. |
| KS1.2.3 | Analyze data to look for patterns or to test whether data are consistent with an initial prediction. |
| KS2.1.1 | Identify what a star is. |
| KS2.1.3 | Understand that some stars appear brighter due to their relative distance from Earth. |
| KS2.1.4 | Develop a basic understanding of apparent magnitude and absolute magnitude of stars. |
| KS2.2.1 | Develop a basic understanding of Earth's place in the universe. |
| KS3.2 | Explain the observable phenomena of day and night, daily changes in the direction and length of shadows, and different positions of the Sun, Moon, and stars at different times of the day, month, and year. |
| KS3.3 | Explain how Earth rotates on an axis. |
| KS3.4 | Explain how Earth orbits the Sun. |
| KS4.5 | Attend to precision. [CCSS.MATH.PRACTICE.MP6] |
| KS4.7 | Organize and present collected data visually to highlight relationships and support a claim. [CSTA 1B-DA-06] |
| KS4.8 | Use data to highlight or propose cause-and-effect relationships, predict outcomes, or communicate an idea. [CSTA 1B-DA-07] |
| KS5.1 | Generate ideas as a team. |
| KS5.2 | Value the contributions of each team member. |
| KS5.3 | Demonstrate collaboration through effective communication. |
| KS6.1 | Document work in an organized notebook. |
| KS6.2 | Explain findings and justify evidence-based conclusions with others. |
| KS6.3 | Present data and information accurately and effectively. |
| KS6.4 | Critique the explanations or solutions proposed by other students by citing evidence about the natural and designed world(s). |
| KS7.1 | Engage in and maintain positive interactions and relationships with other children and adults. |

## Preparation

### Part 1. Earth's Rotation

In Part 1, students discuss cardinal directions and determine how the classroom is oriented to the cardinal directions. Before you begin the project, use a compass to find north, south, east, and west.

### Part 2. Tracking Stars Across the Sky

1. Review the Procedure to facilitate the scientific inquiry process with students.
2. If needed, review the Scientific Inquiry Process video found in Activity 2.
3. Review the Images of the Night Sky presentation in the student course so you can explain to students how to interpret these images.
4. Locate Perseus in the Images of the Night Sky presentation. Review the sketch of Perseus that represents its position in the night sky over the course of a year.

**Time**: 110 Minutes

## Introduction

In this project, students explore Earth's place in the universe and how its *rotation* and *orbit* affect our view of *stars* in the night sky. Students discover how their classroom is oriented to the four *cardinal directions* and make observations to understand how the direction they face affects what is observable. Through discussion, students relate this experience to Earth rotating on its *axis* and what this means for viewing stars.

Then, students use the *scientific inquiry process* to investigate how Earth's movement affects the seasonal appearance of stars in the night sky.

| | |
|---|---|
| cardinal directions | The directions of north, east, south, and west. |
| constellation | A group of stars that appears to form an image and has been given a name. |
| orbit (noun) | The curved path of an object around a star, planet, or moon. |
| pattern | Something that is repeated over and over. |
| rotation | The act of turning around on a fixed point. |
| scientific inquiry process | A process that scientists use to explore observations and answer questions. |
| star | A huge sphere of very hot, glowing gas that produces its own light. |
| Sun | The star at the center of our solar system. |

### Possible Student Misconceptions

- **As Earth rotates around the Sun, the other planets and stars are stationary. They are always in the same location in the night sky**. The other planets in our solar system are in motion, orbiting the Sun like Earth. Our entire solar system is also in motion, moving through space as part of the Milky Way galaxy. The stars and constellations appear to move across the sky because Earth spins on its axis and revolves around the Sun.
- **All objects in the universe that we can see emit light**. We can see the Moon, but it does not emit light. It reflects light. Other planets and moons across the universe reflect light from their stars toward us.
- **There is more than one star in our solar system**. Our solar system includes the Sun, the planets, their moons, and other rocks that orbit around it.

## Procedure

### Part 1. Earth's Rotation

1. Direct students to access the project in the student course and have them read the Introduction.
2. Have students prepare their PLTW Launch Logs for the project.
3. Lead a discussion to activate students' prior knowledge about Earth's patterns in relation to the Sun.

- What type of patterns does Earth's orbit around the Sun create?
  Direct students to access the flashcard examples as you review the vocabulary terms *pattern* and *orbit*.
- What type of patterns does Earth's rotation create?
  Direct students to access the flashcard example as you review the vocabulary term *rotation*.
- How does the Sun appear to move through the sky?
  Direct students to access the flashcard example as you review the vocabulary term *cardinal directions*.

4. Place students in small groups and give each group four sticky notes. Direct students to label each sticky note with one of the cardinal directions. Have students use a compass or compass app to identify the cardinal directions in the classroom. Direct students to place their labeled sticky notes in the correct location. Encourage students to recall how they identified the cardinal directions in Activity 2.

5. Lead a discussion about how students placed their sticky notes.

How did your group determine the cardinal directions?

6. Tell students they will now observe the classroom in each direction. Direct students to face north. Without turning their heads, have students notice what they can observe while facing north. Direct students to record their observations in their Launch Logs. Repeat this process for each cardinal direction.

7. Lead a discussion about the students' observations.

- What can you see when facing north? Do you think a student on the other side of the classroom can see the same things when facing north? Why do you think this?
- Consider everything you were able to see when you faced north. Can you see any of these things when facing south? West? East? Why or why not?

8. Direct students to look at an object that you select in the classroom and face it. For example, students can face your desk, the door, or the board. Then, direct them to turn slowly in a circle.

9. Guide students to complete a Think-Pair-Share on the following questions:
   - Did the object move or did you? How do you know?
   - Your rotation affects your observations. How is this similar to Earth's rotation and what we see in the sky? Why do you think that?

**Note**: Think-Pair-Share is a strategy where students think individually, discuss ideas with a partner, and then share with the whole class. It increases participation and focus.

## Part 2. Tracking Stars Across the Sky

10. Lead a discussion to activate students' prior knowledge about constellations.

- Do you think all objects in the night sky are stars? Why or why not? Direct students to access the flashcard example as you review the vocabulary term *star*.

  Not all objects in the night sky are stars. We might see planets, meteors, and comets.

- What objects can you see when you look up at the night sky?
- Some stars appear to form images in the sky. What are these images called? Direct students to access the flashcard example as you introduce the vocabulary term *constellation*.
- What are some constellations you have observed in the night sky?

11. Explain that students will use the scientific inquiry process to investigate how Earth's movement affects the appearance of constellations in the night sky. Direct students to access the flashcard example as you review the vocabulary term *scientific inquiry process*.

12. **Ask**: Direct students to work with a partner to brainstorm testable questions about how Earth's movement affects how we see constellations.
    - Allow time for each group to share some of their questions with the class. Ask students to share ideas for how you would test questions like those they have presented.
    - Present the testable question for this investigation: How does Earth's movement affect the appearance of constellations in the night sky? Have the students record the testable question in their Launch Logs.

13. **Predict**: Guide students to make a prediction to answer the testable question for this investigation.
    - Remind students that their predictions are claims and should be backed up with evidence from their learning to this point. Have them consider what they observed during the investigations in Activity 3 to make their prediction. The purpose of the investigation is to explore the phenomena to make meaning. Direct students to access the flashcard example as you review the vocabulary term *evidence*.
    - Explain that after they complete the investigation, students will return to their claims and use new evidence to support them or revise them.

- Direct students to record their predictions in their Launch Logs about about how Earth's movement affects the appearance of constellations in the night sky.
- Lead a discussion about the testable question for this investigation.

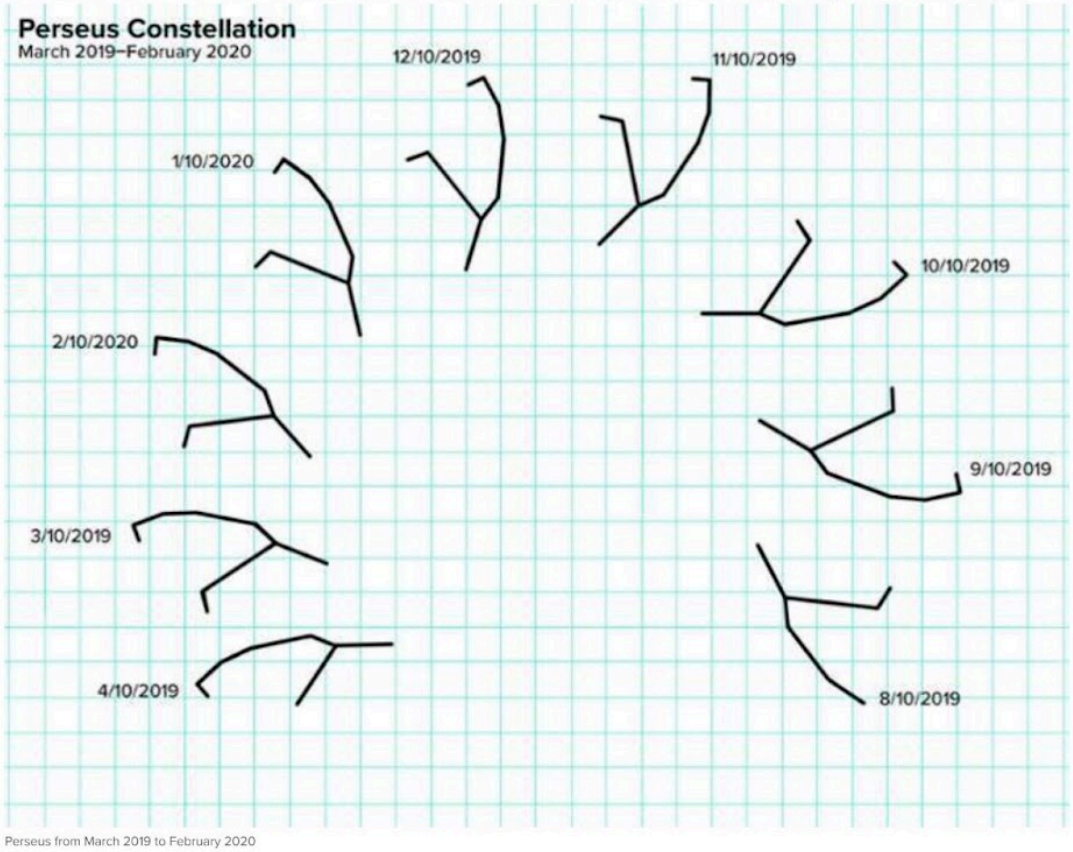
  - How does Earth's movement affect the appearance of constellations in the night sky? Why do you think this?
  - How do you think we could test this question?

14 **Investigate and Observe**: Guide students to test their predictions by carrying out an investigation. During the investigation, have students observe the position of two constellations over the course of a year.

- Have students view the Images of the Night Sky presentation in the student course. Direct them to resize their screen to see the images better. Explain that each image shows the night sky during a different month. Model how to interpret each image to follow the constellations over the course of a year.
- Direct students to work with a partner and use the constellation chart to select two constellations for their investigation. Students should select one constellation from Group A and one constellation from Group B.

| Constellations | |
|---|---|
| Group A | Group B |
| ◦ Camelopardalis<br>◦ Cassiopeia<br>◦ Cepheus<br>◦ Draco<br>◦ Ursa Major<br>◦ Ursa Minor | ◦ Aries<br>◦ Cancer<br>◦ Gemini<br>◦ Leo<br>◦ Pisces<br>◦ Taurus |

- Have students view the sketch of Perseus in the student course. This sketch represents Perseus's position in the sky over the course of a year.




Perseus from March 2019 to February 2020

- Direct students to locate their chosen constellation from Group A in the March 10, 2019 image and draw it in their Launch Logs.
- Before moving on to the next month's image, ask students to predict where the constellation will be in the sky the following month. Have them share this prediction with their partner.
- Repeat this process for all 12 images of Constellation A and Constellation B.
- After recording their observations for all 12 images of Constellation A and Constellation B, direct student pairs to review their drawings to make a conclusion about how the movement of Earth affects the appearance of constellations.

15 **Explain**: Lead a discussion with students to share their observations and conclusions.

- Direct student pairs to join another pair to form small groups of four. Direct each group to discuss and compare their observations and conclusions with each other.
- Guide students to review their prediction (claim). They should confirm the claim with evidence or update their claim based on the evidence from their investigation.
- Lead a discussion about students' observations and answers to the testable question.



- Did each group's constellations appear to move in the same predictable pattern? Why or why not?
- Did the evidence you gathered support your claims? Why or why not?
- Based on your evidence, how does Earth's movement affect the appearance of constellations in the night sky?
- Why are we not able to see all the constellations all year long?

> We are not able to see all the constellations due to Earth's orbit around the Sun. As Earth orbits the Sun, our view of space changes.

**Note**: If students are having a difficult time making conclusions based on their observations, bring out some of the models from previous activities to help demonstrate Earth's rotation and orbit around the sun. Modeling these with the constellations in mind can help solidify the reasons behind the stars' apparent movement. Suggestions:

- Model how Earth rotates on its axis. This axis points to a specific area all year round, no matter where the orbit around the Sun takes us. Polaris, also known as the "North Star," is very close to the projection of Earth's axis into space. If you watch Polaris throughout the year, it moves in a very tight circle. This explains the motion of constellations in Group A. These stars are seen in the area of space closest to the projection of the axis, so they are seen all year long.
- Model Earth rotating around the Sun. As Earth moves around the Sun, it travels 940 million miles over the course of the year. Earth is in vastly different locations when you compare its location in winter versus its location in summer. As a result, we see different constellations in winter and summer. This explains how constellations in Group B appear to move in and out of view seasonally.

16 Guide students to answer the Conclusion Questions. Lead a discussion for students to share their thoughts.

## Conclusion Questions Answer Key

1 How does Earth's rotation affect how we see stars in the sky? Support your answer with evidence.

> Student responses should demonstrate an understanding of how Earth's movement affects the appearance of constellations. Responses might include:
> Because of Earth's rotation, the stars appear to move in the sky in a circular pattern. Some constellations, such as Cepheus, appear to move in a tight circle. Other constellations, such as Gemini, move in a wide circle.

2 How does Earth's orbit around the Sun affect how we see stars in the sky? Support your answer with evidence.

> Student responses should demonstrate an understanding of how Earth's movement affects the appearance of constellations. Responses might include:
> Over the course of each season, we are on different sides of the Sun, so we face different areas of space. Because of this, we do not see all the constellations year round. For example, Pisces can only be seen during certain months of the year.

3 Earth is divided into sections called hemispheres. The equator divides the northern and southern hemispheres. How would your view of the night sky be different if you moved from the northern hemisphere to the southern hemisphere or the southern hemisphere to the northern hemisphere? Why do you think this?

> Student responses should demonstrate an understanding of how Earth's movement affects the appearance of constellations. Responses might include:
> If I moved to a different hemisphere, my view of space would be different. The constellations that appear to move in a tight circle are close to the projection of Earth's axis. That means, if I live in the northern hemisphere, I see the constellations that are close to the projection of the Earth's axis in the north. If I moved to the southern hemisphere, I would see the constellations that are close to the projection of the Earth's axis in the south.

Problem

# Space Science Exhibit

Teacher Resources

View Student Course

## EQUIPMENT

The list below is based on a class of 30 students.

| Included in Equipment Kit | Not Included in Equipment Kit | Device Applications |
|---|---|---|
| • Card stock<br>• Blue modeling clay<br>• Gray modeling clay<br>• Wooden dowels<br>• Rounded toothpicks | • PLTW Launch Logs (1 per student)<br>• Digital devices<br>• Pencils or colored pencils for sketching<br>• Chart paper<br>• Markers<br>• Display boards, such as:<br>  ◦ Poster board<br>  ◦ Tri-fold board<br>  ◦ Project board<br>  ◦ Foam board | • Inkling<br>• Camera<br>• Digital product apps, such as:<br>  ◦ Video function on device<br>  ◦ Popplet Lite<br>  ◦ Mindomo<br>  ◦ ShowMe Interactive Whiteboard<br>  ◦ iMovie<br>  ◦ Quik<br>  ◦ Kapwing<br>  ◦ Scratch |

## RESOURCES

R

Research Resources

Decision Matrix

Summative Assessment

## ESSENTIAL QUESTIONS

EQ

EQ1 What is Earth's place in the universe?

EQ2 How do the predictable patterns of Earth impact our lives?

EQ3 How can a step-by-step process help you design or improve a solution to a problem?

## LEARNING OBJECTIVES

LO

LO1.1 Follow a step-by-step method to solve a problem.

LO1.2 Use scientific reasoning to ask questions, make observations, and investigate ideas to acquire knowledge and solve problems.

LO2.2 Understand the universe includes all the natural bodies in space.

LO4 Apply mathematical thinking to solve problems.

LO5 Collaborate effectively on a diverse and multidisciplinary team.

LO6 Communicate effectively for specific purposes and settings.

LO7 Practice ethical behavior in all settings.

## KNOWLEDGE AND SKILLS

KS

| | |
|---|---|
| KS1.1.1 | Define a simple design problem reflecting a need or a want. |
| KS1.1.2 | Brainstorm possible solutions to the problem. |
| KS1.1.3 | Evaluate a solution through observations and/or measurements and consider what revisions to the initial solution are needed. |
| KS1.1.4 | Identify the evidence that supports particular points in an explanation. |
| KS1.2.1 | Ask and identify questions to gain knowledge or solve problems. |
| KS2.2.2 | Create an interactive, space science exhibit to share with an audience. |
| KS4.1 | Make sense of problems and persevere in solving them. [CCSS.MATH.PRACTICE.MP1] |
| KS4.3 | Construct viable arguments and critique the reasoning of others. [CCSS.MATH.PRACTICE.MP3] |
| KS4.5 | Attend to precision. [CCSS.MATH.PRACTICE.MP6] |
| KS5.1 | Generate ideas as a team. |
| KS5.2 | Value the contributions of each team member. |
| KS5.3 | Demonstrate collaboration through effective communication. |
| KS6.1 | Document work in an organized notebook. |
| KS6.2 | Explain findings and justify evidence-based conclusions with others. |
| KS6.3 | Present data and information accurately and effectively. |
| KS6.4 | Critique the explanations or solutions proposed by other students by citing evidence about the natural and designed world(s). |
| KS7.1 | Engage in and maintain positive interactions and relationships with other children and adults. |

# Preparation

## Professional Development

Before you facilitate the problem, access the **Launchpad** to review:

- Thinking Like an Engineer
- Developing Research Skills with Elementary Students
- Integrating Technology and Promoting Online Safety
- Staying Safe and Secure! Interactive Experience

## Problem

1. Become familiar with the procedures for facilitating this problem with your students. In this problem, students create a visual display and an interactive digital component for their exhibit. Students may wish to include a model in their exhibit, but this is not required.
2. During the Explore step of the design process, the class brainstorms possible topics about space science to research for their exhibits. After the class brainstorm, students choose the specific topic they want to research for their exhibit. Consider how you will group students so that each student is able to research and design an exhibit for a topic they are interested in.
3. During the Explore step of the design process, students research their chosen topic in space science. Review the **Research Resources** and gather books, websites, articles, and other materials that students can use during the Explore step of the design process.
4. In this problem, students use an iterative process to create a rough draft of their exhibit and then create a final draft. To do this, they complete the Model and Evaluate steps twice. In the initial Model step, students create a rough draft of their exhibit materials to share with peers and receive feedback during the Evaluate step. After they create a draft and receive feedback, students complete the Model and Evaluate steps a second time. This time, students create their final exhibit and evaluate within their group.
5. During the initial Evaluate step of the design process, students engage in peer review to present and receive feedback on the rough draft of their exhibit. Each group will pair with another group to share their rough draft and get feedback. Plan how you will create and organize peer review groups.
6. Think of ways for students to present their exhibits outside of the classroom. Options include presenting at a local library, museum, or school board meeting. If students are unable to present outside the classroom, invite guests to observe student exhibits. Guests can include parents, school board members, and local community leaders.
7. As students work through the design process to develop a solution, use the Summative Rubric to assess their demonstration of learning. A printable version of the rubric is accessible in the Resources section on the **Summative Assessment** page. Use the rubric as a guide throughout the process of solving the problem.
8. Become familiar with the **Decision Matrix**. The decision matrix is a tool that allows students to rate the designs based on the criteria. If desired, you can print a copy of the decision matrix for each student to complete and glue in their Launch Log.

**Time**: 180 Minutes

# Introduction

In this problem, students follow the *design process* to research, design, and evaluate an exhibit that teaches and engages an audience about a topic of space science. Students present their exhibits to their classmates or the larger school community.

| | |
|---|---|
| constraint | A limitation or a restriction. Constraints include limits on time, materials, and size. |
| criteria | Guidelines or rules used to judge or make a decision about something. |
| design process | A step-by-step way to solve problems. |

# Procedure

1. Review the Introduction Story: *A Shooting Star* with students. Remind students that their challenge is to design an exhibit to teach others about space science.
2. Direct students to access the problem in the student course and have them read the Introduction.
3. Direct students to access the flashcard example as you introduce the vocabulary term *design process*.
   - Ask students to share examples of how they have used a step-by-step process to complete a task. Examples include:
     - Getting ready for school
     - Brushing their teeth
     - Solving a math problem
     - Making a snack
   - Explain to the students that they are going to use the same steps that engineers use to design new items and improve existing items.
4. Present the Design Process video as an introduction to engineers and the design process.




Design Process video

5 Lead a discussion about what students learned from the Design Process video.

- Why do engineers use the design process?
- How do you think the design process helps engineers in their work?
- Why is it important to ask questions as you work through the design process? Why do you think that?
- In the video, we learned that it is important to understand the problem before looking for a solution. Have you ever identified a problem and then looked for a solution? Allow students to share their thoughts.

6 For the problem, the PLTW Launch Log has a guided section titled, "Solving the Problem." Guide students to locate and preview this section in their Launch Logs. Students record notes, sketches, and ideas for each step of the design process. Remind students that it is important to include details that provide evidence for their thinking throughout the process.

7 Guide students to follow the design process to design a space science exhibit.

8 The first step in the design process is **Ask**.

- Have students consider what they learned about the Ask step in the Design Process video. In this step, students ask questions to make sure they have a clear understanding of the problem and the criteria and constraints for their design.
- Guide a discussion where students ask questions to gather information that will help them define the problem.
- With support and guidance, the students define the problem, "How can I design an exhibit that teaches and engages others about a topic in space science?"
- Explain that when engineers solve problems, they have to follow the *criteria* and *constraints* for the solution. Use the flashcard examples as you introduce or clarify the vocabulary terms *criteria* and *constraint*.
- Introduce the criteria and constraints of the design.

| Criteria | Constraints |
|---|---|
| The exhibit:<br>• Includes a goal that states what the audience will learn.<br>• Includes at least five facts and three pictures aligned to the exhibit goal.<br>• Includes a visual display, such as a tri-fold board, poster board, chart, or model.<br>• Includes an interactive, digital component aligned to the exhibit goal.<br>• Cites sources used in researching the topic.<br>• Is designed for the right audience. | • Time<br>• Space on the visual display to fit information<br>• Digital product apps<br>• Available research |

- Guide the students in a discussion to consider the problem, criteria, and constraints.

- What does it mean for an exhibit to have a goal for its audience? Can you think of an example goal from a museum that you visited? Why is this a necessary part of a science exhibit?

  > The goal is what people should learn when they visit the exhibit. For example, the Children's Museum Indianapolis has an exhibit titled "Take Me There®: Greece." The goal of this exhibit is for everyone to learn about Greek culture. Goals are important for the exhibit designers. They must make sure all components of the exhibit address the goal. Also, exhibit goals provide the audience with an overview of what they will learn.

- What does *interactive* mean when talking about a science exhibit?
- Many museum exhibits are designed to be observed or listened to. Other exhibits may be interactive. They require you to actively engage in some way. Why do you think that interactive experiences are important in an exhibit?
- Why do you think space for information is an important constraint?
- What audience will experience your exhibit? How should you design your exhibit to meet the needs of this audience?

  > **Note**: The way you frame this question will depend on how students will present their final exhibits and to what audience. Will they be viewed by mainly younger elementary students, parents, the entire school community, or the public? Lead students to consider how they would design their exhibit differently based on the audience.

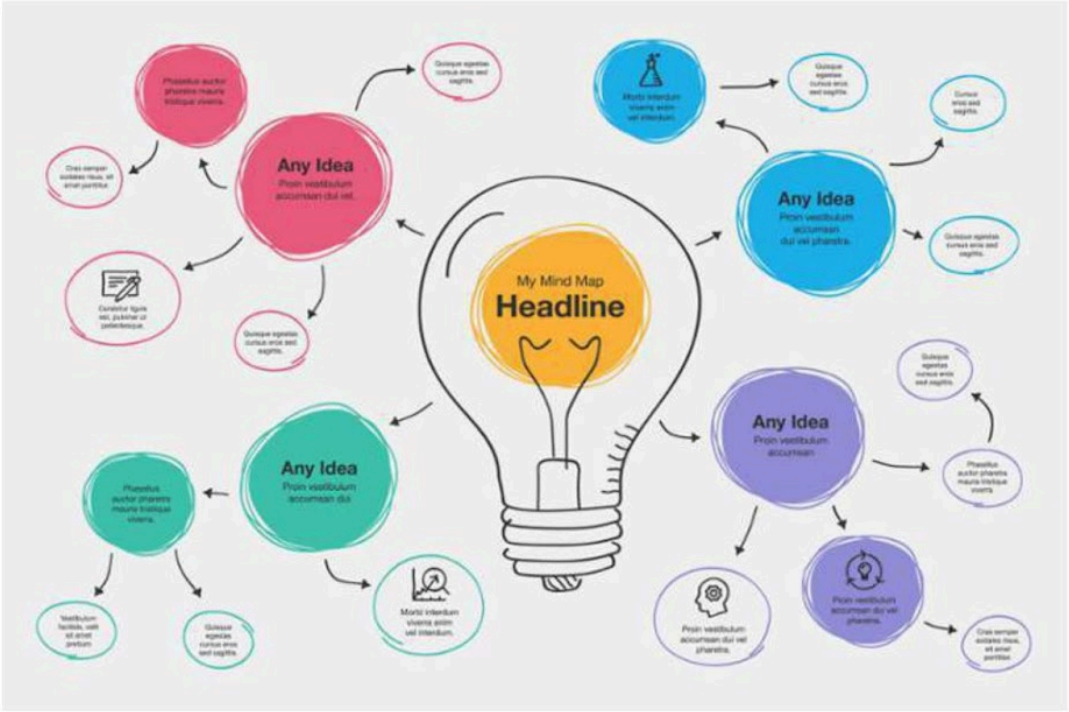
- What do you think *citing sources* means? Why is it important to cite sources?

- Guide students to record their responses in the Ask step of their Launch Logs.
- Have students complete the self-reflection at the end of the Ask section in their Launch Logs. Guide students to circle one statement in each row. Assess student understanding and record comments as needed.

> **Note**: At the end of each stage of the design process, students complete a self-reflection. This self-reflection is intended for students to provide honest feedback about their skills during each stage. They are not expected to be "advanced" in all areas all the time. Explain to students that this self-reflection is intended to help them grow as problem-solvers.

9 The second step in the design process is **Explore**.

- As a class, guide students to brainstorm topics about space science they would like to research for their exhibits. Record their responses on chart paper, grouping similar ideas together. If needed, prompt students to recall specific topics and activities from the module, such as stars and constellations, the Sun, the Moon, and Earth and its patterns.
- After the class brainstorm, direct students to select a topic that interests them. Group students according to shared interests.
- Guide students to research their topic. See **Research Resources** for research options.
- Have students record their research findings in the Explore section of their Launch Logs.
- Direct students to create simple citations for the sources they use. For example:
  - The Moon Book by Gail Gibbons
  - What Is Earth? (nasa.gov)
- Direct students to create a concept map for their exhibit based on their research. This should outline the specific topics students want to present in the exhibit.




- Guide students to brainstorm several ways to present their exhibit in an interactive manner.

  - What museums have you visited? How did their exhibits get your attention? How did you interact with their exhibits? What did you learn or experience?
  - What activities in this module were interactive? Could you model an exhibit on something you experienced during our lessons?
  - During your research, what sources made learning about your topic easier or more exciting? Compare and contrast how websites and books present information.

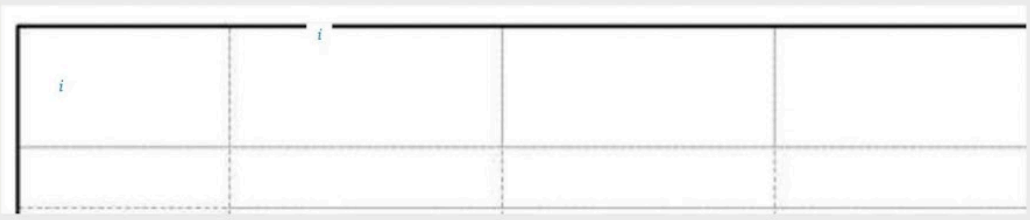
- In the corresponding section of their Launch Logs, direct students to record ideas and use labeled sketches to detail their exhibit, its components, and the information it will share.
- Have students complete the self-reflection at the end of the Explore section in their Launch Logs. Assess student understanding and record comments as needed.

10 The third step in the design process is **Model**.

> **Note**: In the initial Model step, students create a rough draft of their exhibit materials to share with peers and receive feedback in the Evaluate step. After they create a draft and receive feedback, the students complete the Model and Evaluate steps a second time. During the second time, students create their final exhibit and evaluate it within their group.

- Introduce a decision matrix as a way to decide on the best design. Using the **Decision Matrix**, students rate each group member's design based on a 0–1 scale for each category. If the design does not meet the criterion in a category, it receives a 0 in that category. If the design does meet the criterion, it receives a 1. The design with the highest total score offers the best solution from the group.

> **Note**: Students may use the decision matrix in their Launch Logs or the copy you provide. If they use the one in their Launch Logs, they need to complete the column and row headers as shown.




- Have students share their concept maps with the group and complete the decision matrix as ideas are shared.

- As a group, create a new concept map for the exhibit. This concept map should include:
  - The exhibit goal
  - The exhibit topics
  - Ideas for images for the visual display
  - Ideas of what to include in the interactive, digital component and possible format
  - Sources
- Guide students to use the chosen design to create a rough draft of their exhibit, which includes all text for the exhibit and a graphic organizer for the interactive, digital component.
- To facilitate the creation of the exhibit drafts, circle around the room and assess student progress. Ask students to share their ideas and their thinking with you as they work.

> **Note**: This is a good opportunity to direct students to focus on supporting the claims they made in their exhibits with evidence and to cite reputable sources. Also, if appropriate, encourage students to use mathematical skills such as modeling with mathematics, representing data in graphical displays to reveal patterns, and organizing collected data visually to highlight relationships to support a claim.

11 The fourth step in the design process is **Evaluate**.

> **Note**: In this first iteration of the Evaluate step, students work in peer review groups to give and receive feedback on the rough draft of their exhibit.

- Explain to students how they will engage in peer review to determine how well their exhibit meets the design criteria for the problem.
- Direct student groups to pair with another group for peer review. Each group will take turns sharing their ideas, exhibit goal, and rough draft with the other group.
- Direct peer review groups to evaluate whether the exhibit meets the criteria, consider whether everything included supports the goal of the exhibit, and offer feedback on the overall exhibit. Provide guidance so that each group has a turn to share and receive feedback.

> **Note**: Peer review is a valuable tool to encourage students to think critically about their own work and the work of others. However, peer review should be carefully planned and guided, especially for students new to or unfamiliar with the process.
>
> As you prepare for peer review, consider, and plan for, additional support your students may need to be strong reviewers and provide constructive feedback. Consider the following:
> - Provide clear directions for what students should look or listen for in their peer's work. Some basic questions that can help students focus their review:
>   - Do you understand what the exhibit is about?
>   - Does this exhibit seem interesting?
>   - What can you learn from this exhibit?
>   - Does everything the group says make sense?
>   - Does the exhibit meet the criteria?
> - Provide sample language or sentence starters for strong peer review, such as:
>   - One thing that works well is...
>   - I think it is really engaging how...
>   - You do a good job explaining...
>   - One thing you could do to make it stronger is...
>   - To better meet your exhibit goal, you could try...
>   - You can make the explanation of _____ stronger by...
> - Model the process. Demonstrate how to review a peer's work and how to provide feedback.

- After the group feedback, guide the original design groups to reflect on the strengths and weaknesses of their exhibit.



- Does the text match the exhibit's goal?
- How can we improve our exhibit based on the feedback we received?
- What type of pictures will improve the exhibit?
- How do you plan to present your facts and pictures on your visual display?
- How will the interactive, digital component address the exhibit's goals?

- Have students record the strengths and weaknesses of their designs and record them in the corresponding section of their Launch Logs. They will make improvements based on this feedback as they create their final exhibits.

12 **Model** the final exhibits.

- Guide students to create their final exhibit. Direct students to the available materials, such as wooden dowels, modeling clay, card stock, toothpicks, markers, pencils, tri-fold board, poster board, or chart paper.

- Direct students to create their exhibit using the media that best suits their content, such as pictures and text, slideshows, models, and programmed interactive content on their digital device.
- To facilitate the creation of the final exhibits, circle around the room and assess student progress. Ask students to demonstrate how their final products improve upon their rough drafts.
- Have students complete the self-reflection at the end of the Model section in their Launch Logs. Assess student understanding and record comments as needed.

13 **Evaluate** the final exhibits.

- Tell students they will evaluate their own exhibit to determine how well their exhibit meets the design criteria for the problem.
- Explain that many museums use feedback questionnaires to let guests provide input that helps them determine whether the exhibit was a success. Support students in identifying what conditions would indicate a successful space science exhibit and direct them to design a feedback questionnaire to evaluate their exhibit.
  - A design is successful if someone with no prior knowledge of a topic visits the exhibit and learns the stated goal. A feedback questionnaire might state, "Using a 5-point scale, rate how much you knew about this topic before viewing the exhibit." Also, "Using a 5-point scale, rate how much you know about the topic now."
  - The questions can be simple yes/no questions and should ask about the information presented as well as how engaging the visual and digital components are.
  - Direct students to record their questions in their Launch Logs.
- Direct students to pretend they are a visitor at their own exhibit and complete the questionnaire they designed as if they are interacting with this information for the first time. Direct students to record their responses in their Launch Logs.
- Direct students to share their thoughts and responses within their group and discuss the strengths and weaknesses of their exhibit. Guide exhibit groups to record their thoughts in the corresponding section of their Launch Logs.
- Have students complete the self-reflection at the end of the Evaluate section. Assess student understanding and record comments as needed.

14 The fifth step in the design process is **Explain**.

- Allow time for students to present their exhibits.

> **Note**: Presentations will vary depending on the audience. If students are presenting to parents, school board members, local community members, or students from other classrooms, have your students remain at their exhibit to present.
>
> If your students are just presenting to each other, divide the class in half. Have half of the class remain at their exhibits to present while the other half completes a gallery walk. Then, switch roles so all students present and interact with the exhibits.

- After students view and interact with all exhibits, lead a discussion about their features, strengths, and weaknesses.

  - Did your exhibit meet its goal? Why or why not?
  - Did your exhibit engage the audience as you expected? Why or why not?
  - Did your exhibit cover the same or similar material as another? Did that exhibit present the content in a similar or different way than yours?
  - If you could improve anything about your exhibit, what would you improve? Why would you improve that aspect?

- Guide students to complete the Explain section of their Launch Logs. Have students provide suggestions for improvement for their exhibit and support those with evidence.
- Have students complete the self-reflection at the end of the Explain section in their Launch Logs. Then assess student understanding and record comments as needed.

15 Guide students to answer the Conclusion Questions. Lead a discussion for students to share their thoughts.

16 Direct students to complete the Patterns in the Universe Check for Understanding. You can access a printable version of this assessment in the Resources section of the **Summative Assessment**.

## Conclusion Questions Answer Key

1 What did you learn from other exhibits?

Student responses will vary.

2 List two changes you would make to improve your design. Why do you think these two changes would improve your exhibit?

Student responses will vary.

3 If you could research a new topic about space, what would you choose? Why do you want to learn more about that topic?

Student responses will vary.

Introduction to the Module

# Robotics and Automation

Teacher Resources



**Distance Learning Support**

For information about PLTW's distance learning support and online learning guides, jump to Distance Learning Support in **PLTW Launch Module-specific PD Resources**.

For distance learning support for facilitating this module, jump to **Distance Learning Support: Robotics and Animation Teacher Guide**.

## PREFACE

**Time:** 10 instructional hours

In this module students explore robotic history and learn more about a particular type of robot. The activities and projects in this module develop skills and knowledge associated with robotics and the use of VEX® IQ equipment.

The problem for this module is introduced through a fictional story in which the three characters (Angelina, Mylo, and Suzi) are also learning about robotics. The characters learn about the use of robots in the clean up after a natural disaster at a nuclear plant. In this design problem, students work with a group to design, model, and test a robot that can remove hazardous materials from a disaster site. They also design the layout of the site to include a water site and a hazardous materials collection zone.

## TRANSFERS

T

T1 Evaluate a problem in a new and novel situation.
T2 Apply a step-by-step design process to solve a problem.
T3 Apply scientific ideas to address human needs and wants.

## ESSENTIAL QUESTIONS

EQ

EQ1 How can automation and robotics be used to protect the Earth's resources and environment?
EQ2 How can the engineering design process be applied in daily life?

## UNDERSTANDINGS

U

U1 Scientists and engineers use standard practices to explain the world or solve problems.
U2 Crosscutting concepts are used across all disciplines of science and engineering to make sense of phenomena.
U3 Natural and human actions are related to environmental challenges.
U4 Mathematical thinkers apply complex thinking and reasoning strategies where thinking is intentional and reflected upon.
U5 Mathematical thinkers apply complex thinking and reasoning strategies where thinking is intentional and reflected upon.
U6 Professionals function effectively and efficiently on multidisciplinary teams to be successful.
U7 Professionals communicate effectively with a variety of audiences using multiple modalities to be successful.
U8 Professionals conduct themselves so as to maximize benefits for society and minimize harm.

## LEARNING OBJECTIVES

LO

- LO1.1 Follow a step-by-step method to solve a problem.
- LO1.2 Use scientific reasoning to ask questions, make observations, and investigate ideas to acquire knowledge and solve problems.
- LO2.1 Understand that events have causes that generate observable patterns.
- LO2.2 Understand that a system is an organized group of related objects or components and that models can be used for understanding the and predicting the behavior of systems.
- LO3 Understand that science ideas can be used to protect humans, Earth's resources, and its environment.
- LO4.1 Understand that automation and robotics can be used to complete a task that would cause a safety hazard for humans.
- LO4.2 Analyze how sensors provide input to automated and robotic systems which can be used to adjust the behavior of outputs.
- LO5 Apply mathematical thinking to solve problems.
- LO6 Collaborate effectively on a diverse and multi-disciplinary team.
- LO7 Communicate effectively for specific purposes using the appropriate platform, tool, format, or digital media.
- LO8 Practice ethical behavior in all settings.

## KNOWLEDGE AND SKILLS

KS

- KS1.1.1 Understand what happens at each step of the design process.
- KS1.1.2 Define a simple design problem reflecting a need or a want.
- KS1.1.3 Brainstorm possible solutions to the problem.
- KS1.1.4 Make and use a model to test a design or aspects of a design, and to compare the effectiveness of different design solutions.
- KS1.1.5 Evaluate a model solution through observations and/or measurements and consider what revisions to the initial model are needed.
- KS1.2.1 Ask and identify questions to gain knowledge or solve problems.
- KS1.2.2 Make observations to draw conclusions of phenomena.
- KS1.2.3 Analyze models as an explanation of phenomena.
- KS1.2.4 Understand that science findings are limited to questions that can be answered with evidence.
- KS2.1.1 Identify cause and effect relationships.
- KS2.1.2 Use cause and effect relationships to explain change.
- KS2.1.3 Analyze data to look for patterns or to test whether data are consistent with an initial prediction.
- KS2.2.1 Understand that system is a group of related parts that make up a whole.
- KS2.2.2 Recognize that a system can carry out functions that its individual parts cannot do alone.
- KS2.2.3 Describe a system using its components and their interactions.
- KS3.1 Explore ways to protect Earth's resources and its environment.
- KS3.2 Use science ideas to model how to safely remove hazardous waste during a disaster.
- KS3.3 Understand that people's needs and wants change over time
- KS3.4 Understand that engineers improve existing technologies for different reasons.
- KS4.1.1 Draw evidence from informational texts to support analysis, reflection, and research on robotics.
- KS4.1.2 Identify applications of robot technology used to complete tasks.
- KS4.1.3 Understand that automated systems control devices with minimal human intervention.
- KS4.1.4 Demonstrate the functionalities of a vehicle designed to complete a task related to protecting the Earth's resources and environment.
- KS4.2.1 Identify inputs and outputs within a robotic system.
- KS4.2.2 Design a control system to use sensor feedback to make decisions.
- KS4.2.3 Use motors and sensors to solve robotic problems.
- KS4.2.4 Select appropriate tools to strategically solve a robotics problem.
- KS5.1 Make sense of problems and persevere in solving them. [CCSS.MATH.PRACTICE.MP1]
- KS5.2 Use appropriate tools strategically. [CCSS.MATH.PRACTICE. MP5]
- KS5.3 Attend to precision. [CCSS.MATH.PRACTICE.MP6]
- KS6.1 Generate ideas as a team.
- KS6.2 Demonstrate teamwork through effective communication.
- KS6.3 Demonstrate flexibility and adaptability.
- KS7.1 Document work in an organized notebook.
- KS7.2 Explain findings and justify evidence-based conclusions with others.
- KS7.3 Present data and information accurately and effectively.
- KS8.1 Engage in and maintain positive interactions and relationships with other children and adults.
- KS8.2 Value and credit the contributions of others.
- KS8.3 Recognize that one's behavior impacts those around them.



# SPRINGFIELD PUBLIC SCHOOLS

**ENGAGING STUDENTS • FOSTERING ACHIEVEMENT • CULTIVATING 21ST CENTURY GLOBAL SKILLS**

RESOURCES

- Curriculum Framework
- Connections to Standards
- Fifth Grade Connections to Standards
- Family Letter
- Additional Instructional Resources
- Fifth Grade Curriculum Revisions
- Device Specifications
- Application List

## Preparation

**Note:** In preparation for teaching this module, it is strongly recommended that the teacher read the Robotics and Automation Teacher Resources, including the Understandings, Knowledge, and Skills addressed in the module. Detailed instructions are provided in the Teacher Resources for each activity, project, or problem.

### Accessing VEX IQ Component Assembly Instructions

***Using Fusion 360—an alternative, browser-based tool. Note that this does not require the installation of an app.***

*Students may access the links for building with VEX IQ components by selecting the Fusion 360 links in the student procedures. If you are presented with an option to install an app, ignore this and select the Continue in Browser option.*

*If a Fusion 360 link does not work, close the web browser entirely and select the link again to open the Fusion 360 tool.*

***Using a video—if Fusion 360 is unavailable***

*In a situation where the browser cannot be used to view the steps, videos are available in the student course, titled Testbed Video Resource and Chassis Video Resource. Direct students to use the videos only if Fusion 360 is not accessible.*

**Note:** There are two versions of the PLTW VEX IQ Robot Design Kit. Either kit version may be used to construct the assemblies required for this module.

Make sure that the VEX IQ equipment is prepared for this module, including charging the controllers and batteries. The VEX IQ equipment firmware also needs to be updated. Refer to pages 1-4 on the VEX IQ Setup with VEXCode IQ Blocks App document found on the **PLTW Software** page for guidance. A Windows® or Mac computer is required to download VEXos. See **https://www.vexrobotics.com/vexiq/resources/ vexos** for more information.

Additional resources are available at the VEX IQ website: **http://www.vexrobotics.com/vexiq.** If you choose to use the optional VEX IQ field, an assembly guide is included in the Resources section of the Problem Teacher Resources page.

After the firmware is updated, the equipment should be ready for use in the module. When in use, a controller transmits wireless signals to a robot brain, allowing it to operate a robot without a wire connecting the devices. As more controllers transmit signals within the same space, the possibility of interference increases. This affects how reliably a controller operates a robot. The size of the room where controllers are in use also affects the controller communication—small rooms tend to allow more interference than open spaces. This is analogous to a room filled with people having many conversations. As more people engage in conversation, it becomes more difficult to understand what is being communicated. If robot responses to controller inputs becomes unreliable, then consider moving to a larger room or reduce the number of controllers operating at a time.

## Curriculum Framework and Connections to Standards

Before you facilitate this module, review the Curriculum Framework and Connections to Standards documents.

Standards are the foundation for what is taught in a classroom. They outline what students are expected to learn and be able to do as a result of participating in learning experiences. When planning the implementation of any curriculum, it is essential to identify which standards the curriculum addresses and any standards it does not. This offers greater insight into what the curriculum provides your students and any standards that you may need to address beyond the content provided.

For each PLTW Launch module, teachers are provided a curriculum framework document, which offers a three-stage approach to curriculum planning, assessment, and instruction. The framework document offers a big picture view of the module including the desired results of student learning, assessment opportunities that call for evidence of student learning, and an overview of the scaffolded approach to student learning.

Within the desired results of student learning in the curriculum framework, information is included about module connections to the following standards, when applicable:

- Next Generation Science Standards (NGSS)
- Common Core State Standards (CCSS) in English/Language Arts (ELA) and Mathematics
- Computer Science Teachers Association K–12 Computer Science Standards (CSTA)
- International Society for Technology in Education (ISTE)
- National Association for the Education of Young Children (NAEYC) Early Learning Program Standards
- Head Start Early Learning Outcomes Framework

We understand that your state might not align to these bodies of standards. That is why PLTW Launch is designed for flexible implementation. If your state does not address these standards, spend time comparing your state standards to those identified for the module. Remember that PLTW Launch modules can be implemented at any PreK–5 grade level based on your state standards. Also keep in mind that if you implement a module at a different grade level than indicated, you might need to make modifications to meet the needs of your students.

Exploring this framework resource before you examine the Teacher Guide gives you a high-level understanding of the stages to curriculum planning, assessment, and instruction. You can also determine how the module connects to the required standards for your state. After you have explored the curriculum framework document, you'll be ready to explore the step-by-step instructions in the Teacher Guide.

## Professional Development

### Resources

Before you facilitate the Robotics and Automation module, review the professional development resources.

- Access the **Launchpad** to review:
  - Three Dimensional Learning
  - Claims and Evidence
  - The Teacher as Facilitator
  - PLTW Formative Assessment
  - Using PLTW Launch Logs
  - Uncovering and Addressing Misconceptions
  - The APB Instructional Approach
  - Setting the Stage for APB Learning
  - Thinking Like an Engineer
  - Developing Research Skills with Elementary Students
  - The Design Process Song: Version 1
  - The Design Process Song: Version 2
- Access the **Robotics and Automation Module-specific PD Resources** to review:
  - Robotics and Automation APB Overview
  - Accessing Additional PD Resources

### Transportable Skills

PLTW learning experiences offer opportunities for students to build transportable skills they can use in the classroom and beyond. Transportable skills include problem-solving, critical and creative thinking, collaboration, communication, and ethical reasoning and mindset. As a facilitator of learning, you play a vital role in fostering the development of these skills as students explore phenomena.

To build your understanding of how transportable skill development is embedded within PLTW Launch and discover literature connections that illustrate these skills, explore these resources in the **Launchpad**:

- Developing Transportable Skills
- Transportable Skills: Literature Connections

### Questioning Skills

As you facilitate APB learning, asking probing questions is essential. Within each activity, project, and problem throughout this Teacher Guide, you will notice sample prompts to ask your class. The prompts guide you to ask thought-provoking questions, as well as to identify conceptions and misconceptions.

As you work with your students, remember that you are not limited to the prompts provided. The best way to determine the types of questions to ask your students comes from observing and interacting with your students as they engage in the module. This provides formative assessment of students' conceptual development and allows you to uncover and address misconceptions.

Building your questioning skills increases your capacity to facilitate powerful student learning. For more information, review the following professional development resources in the **Launchpad**:

- The Art of Questioning
- Building Your Questioning Skills
- Question Bank

## Family and Community Relationships

Family and community relationships are encouraged throughout the module. A **Family Letter** is provided to introduce Project Lead The Way to families, and encourage families to support students' learning of concepts at home. PLTW recommends that you send this letter to families before you begin a module, to let them know what their students will be learning in school.

FAMILY CONNECTION

In the problem, a Family Connection section is identified by this house icon. This section provides activities families can do to support what students are learning. Families can use the log-in information provided in the Family Letter to access the course activities.

## Developing Vocabulary

Vocabulary learning has been found most effective when active engagement with a term goes beyond just knowing the definition. Rather than presented in isolated lessons, vocabulary is introduced within the context of the activities, project, and problem. Viewing the course on a digital device, students have as-needed access to a glossary and interactive flashcards. Each card has an audio component, so students can independently review these words throughout the module.




0:00 / 0:05

## Icon Legend

Throughout the Teacher Guide, the following icons have special meanings.



### Digital Device

The Digital Device icon indicates times when you or your students will use a device for a learning experience.



### Camera

The Camera icon indicates when you or your students will use a camera for a learning experience. There are many camera options. When possible, the best option is for the students to use the camera on their digital device. However, you might need to assign a class photographer to use a digital camera, or you may be the photographer with the camera on your smartphone.

## Additional Instructional Resources

Project Lead The Way understands the importance of introducing literature, music, and rhyme to students. As such, we created **a list of additional resources** specific to this module. These resources are not included in the equipment kit, and they are not covered in the 10 instructional hours of the module. Incorporating the resources is optional, but they offer ways to provide additional engagement with the concepts explored in this module.

## Curriculum Revisions

The Launch curriculum is continuously updated to provide content and instructional resources that are current and based on best practices. Significant revisions to the curriculum implemented since the prior release of Launch are documented in the **Fifth Grade Curriculum Revisions**.

Activity 1

# Introduction to Robotics

Teacher Resources

View Student Course

## EQUIPMENT

The list below is based on a class of 30 students.

**Note:** The Robotics and Automation module does not have a full or refill classroom kit.

| Not Included in Equipment Kit | Device Applications |
|---|---|
| • Digital devices (1 per group)<br>• Launch Logs (1 per student)<br>• Printed materials about robots (optional). Examples include:<br>• National Geographic Readers: Robots, by Melissa Stewart<br>• DK Eyewitness Books: Robot, by Roger Bridgman<br>• TIME for Kids Explorers: Robots, by Mark Shulman | • Inkling<br>• Internet browser for Robots link<br>• Popplet Lite or ShowMe Interactive Whiteboard |

## RESOURCES

Launch Log Grades 3-5

Introduction to Robotics and Automation

Design Process Worksheet

## ESSENTIAL QUESTIONS

EQ

EQ1 How can automation and robotics be used to protect the Earth's resources and environment?

EQ2 How can the engineering design process be applied in daily life?

## LEARNING OBJECTIVES

LO

LO1.1 Follow a step-by-step method to solve a problem.

LO1.2 Use scientific reasoning to ask questions, make observations, and investigate ideas to acquire knowledge and solve problems.

LO3 Understand that science ideas can be used to protect humans, Earth's resources, and its environment.

LO4.1 Understand that automation and robotics can be used to complete a task that would cause a safety hazard for humans.

LO6 Collaborate effectively on a diverse and multi-disciplinary team.

LO7 Communicate effectively for specific purposes using the appropriate platform, tool, format, or digital media.

LO8 Practice ethical behavior in all settings.

## KNOWLEDGE AND SKILLS

KS

| | |
|---|---|
| KS1.1.1 | Understand what happens at each step of the design process. |
| KS1.2.1 | Ask and identify questions to gain knowledge or solve problems. |
| KS1.2.2 | Make observations to draw conclusions of phenomena. |
| KS1.2.4 | Understand that science findings are limited to questions that can be answered with evidence. |
| KS3.1 | Explore ways to protect Earth's resources and its environment. |
| KS3.3 | Understand that people's needs and wants change over time |
| KS3.4 | Understand that engineers improve existing technologies for different reasons. |
| KS4.1.1 | Draw evidence from informational texts to support analysis, reflection, and research on robotics. |
| KS4.1.2 | Identify applications of robot technology used to complete tasks. |
| KS4.1.3 | Understand that automated systems control devices with minimal human intervention. |
| KS6.1 | Generate ideas as a team. |
| KS6.2 | Demonstrate teamwork through effective communication. |
| KS6.3 | Demonstrate flexibility and adaptability. |
| KS7.1 | Document work in an organized notebook. |
| KS7.2 | Explain findings and justify evidence-based conclusions with others. |
| KS7.3 | Present data and information accurately and effectively. |
| KS8.1 | Engage in and maintain positive interactions and relationships with other children and adults. |
| KS8.2 | Value and credit the contributions of others. |
| KS8.3 | Recognize that one's behavior impacts those around them. |

## Preparation

- Review the Evidence (Stage 2) and Learning Plan (Stage 3) section of the **Curriculum Framework**. Use this tool to plan how you will formatively and summatively assess students throughout this activity.
- Review the **Additional Instructional Resources**. This list includes books that offer diverse perspectives that can expand student understanding. Using these resources provides a sense of inclusion and belonging, and helps students make connections if the content is new to them.
- Determine ways you can support the development of transportable skills in this module. Examples include calling out ways students demonstrate the skills, asking questions that allow students to reflect on their development of the skills, and integrating books listed in the Transportable Skills: Literature Connections resource.
- Think of ways to establish community relationships throughout the module. To encourage career connections in the classroom, invite local community members to work alongside your students or speak to students about their careers.

## Activity 1: Introduction to Robotics

**120 minutes**

- In this activity students will work in groups to learn about the history of robotics and research a variety of robot classes, including those developed to complete tasks that would be dangerous to humans. Students complete Activity 1: Introduction to Robotics.
- Students should log in to the curriculum course to access the directions for this activity.
- As part of the activity, the teacher reads the Robotics and Automation Introduction, which is a fictional story that introduces the problem. The characters in the fictional story introduce an environmental/robotics design problem as they participate in similar research on robotics. The teacher reads the fictional story of the friends (Introduction, Chapter 1 What is a Robot?) to introduce the characters and the design problem. The Introduction may be accessed in the curriculum course or printed for students.
  - Options for reading the story include working in small groups, sharing the story with the whole class, or assigning students to read the story individually using their devices to access the curriculum course.
  - Discuss the story and the design problem with the class. Explain to students how they will participate in activities and a project that are designed to build the knowledge and skills they will need to develop a robot that can remove "hazardous waste" from a site they will design.
- The teacher leads a short class discussion by posing the questions found in the introduction to Activity 1. (When you think of a robot, what comes to mind? Does your robot image look more like a human or more like a machine? When was the first robot used in manufacturing?)
- Guide students to access and read the Fukushima Dai-ichi Nuclear Disaster resource in the student course. As an alternative, you may read this resource aloud. Address misconceptions.

> **Note**: If misconceptions about the concepts of earthquakes and tsunamis arise, use the **Additional Instructional Resources** or resources in the Weather: Factors and Hazards module as support. Use these resources to help students understand the impact this natural disaster had on the Fukushima nuclear power plant and surrounding communities.

- Lead a discussion about how robots were used to remove hazardous waste at the power plant.

- How did the people at the Fukushima Dai-ichi nuclear power plant protect the environment?

  *They used robots to clean up the hazardous waste that was being discharged into the environment through the atmosphere and into the ocean.*

- Why were robots used at the nuclear disaster, instead of humans? Why do you think that?

  *The radiation levels were high after the tsunami and unsafe for humans. Using robots controlled from afar allowed people to move hazardous waste, collect samples, and monitor levels of radiation.*

- In what ways did the robots act similarly to humans? In what ways did they act differently?

  Student responses should demonstrate an understanding of the robots used at the Fukushima Dai-ichi nuclear disaster. Example response:
  - *The 710 Warrior acted similarly to a human, because it performed like a "firefighter" carrying hoses, climbing stairs, working underwater, and maneuvering over obstacles.*
  - *The Packbot acted differently than a human, because it was able to detect temperature, radiation, toxic chemicals, and environmental oxygen levels.*

- In what other types of natural disasters would robots be helpful? Use evidence to explain your thinking.

  Student responses should demonstrate an understanding of how robots can help humans in natural disasters. Example response:

  *I think a robot would be helpful in a tornado. When there is a tornado, humans stay safe by staying inside on the lowest floor. A robot would be able to stay outside to collect data like temperature and wind speed.*

- The teacher guides the students to read the procedure for Part 2. Clarify questions before starting the research activity.
  - Each student group should create a K-W-L chart as described in Procedure Part 2. Options for completing the chart include paper/pencil or device applications, including the Popplet Lite or ShowMe Interactive Whiteboard apps.
  - After each group completes the "K" and "W" sections of the chart, lead a class discussion to allow groups to share their ideas. Create a class level K-W-L chart from the information shared.
  - Each group uses the Internet or printed materials to conduct research on robots following the detailed Part 2 Procedure. Allow approximately 15 minutes for this part of the activity.
    - Suggested website: **https://robots.ieee.org/**
    - Suggested printed materials:
      - National Geographic Readers: Robots, by Melissa Stewart
      - DK Eyewitness Books: Robot, by Roger Bridgman
      - TIME for Kids Explorers: Robots, by Mark Shulman
  - After research time, record what groups learned in the "L" section of the class K-W-L chart.
- Prior to starting Part 3 of this activity, the teacher introduces students to the Launch Log as a place to document their work throughout the module. Students take notes as they research, create sketches, and answer Conclusion Questions in this notebook.
- For Part 3 of this activity, students explore several robot types and select one example. Students will present findings to the class using an app such as Popplet Lite or ShowMe Interactive Whiteboard.
  - Options for assigning robot type include allowing groups to choose, assigning a type to each group, or drawing a type of robot from a basket.
  - Guide students to follow the directions found in Procedure Part 3.
  - Allow time for students to share their findings with the class.
- When students explore careers, they can see connections between what they are learning and real-world applications. Guide students to read about Dr. Cynthia Breazeal, a roboticist.
- In Part 4, students are introduced to the design process. To prepare students for solving the problem in this module, students access a presentation on the Design Process by logging into the curriculum course and using the app on the device. Prepare copies of Design Process worksheet prior to starting this activity.
  - As students work through the presentation, they use the Design Process worksheet to record responses to questions. This activity can be completed with one copy of the activity per group or one copy per student. Option: Allow students to record their work in the Launch Log.
  - After completion of the presentation, guide students to complete the last two Conclusion Questions. Conduct a class discussion.

## Conclusion Questions Answer Key

**Note**: Conclusion Questions offer an opportunity for formative assessment. You may use them as a whole-class discussion or you may have students record ideas in their Launch Logs.

1 How do robots help people perform tasks?

Student responses should demonstrate an understanding of robots. Example responses:

- *Robots can explore planets and send back information.*
- *Robots can clean floors.*

2 If you were a roboticist, what type of robot would you want to design? What would it be able to do? Draw a sketch of your robot idea.

Student responses will vary.

3 Think about the robot you researched. Which step in the design process would the designers find most difficult? Explain your answer.

Student responses will vary.

Activity 2

# Create a Toy

Teacher Resources

View Student Course

## EQUIPMENT

The list below is based on a class of 30 students.

**Note:** The Robotics and Automation module does not have a full or refill classroom kit.

| Not Included in Equipment Kit | Device Applications |
|---|---|
| • Digital devices<br>• Launch Logs<br>• VEX® IQ Robot Design Kit (1 per group) | • Inkling<br>• ShowMe Interactive Whiteboard or Popplet Lite |

## ESSENTIAL QUESTIONS

EQ

EQ1 How can automation and robotics be used to protect the Earth's resources and environment?
EQ2 How can the engineering design process be applied in daily life?

## LEARNING OBJECTIVES

LO

LO1.1 Follow a step-by-step method to solve a problem.
LO5 Apply mathematical thinking to solve problems.
LO6 Collaborate effectively on a diverse and multi-disciplinary team.
LO7 Communicate effectively for specific purposes using the appropriate platform, tool, format, or digital media.
LO8 Practice ethical behavior in all settings.

## KNOWLEDGE AND SKILLS

KS

KS1.1.1 Understand what happens at each step of the design process.
KS1.1.2 Define a simple design problem reflecting a need or a want.
KS1.1.3 Brainstorm possible solutions to the problem.
KS1.1.4 Make and use a model to test a design or aspects of a design, and to compare the effectiveness of different design solutions.
KS1.1.5 Evaluate a model solution through observations and/or measurements and consider what revisions to the initial model are needed.
KS1.2.1 Ask and identify questions to gain knowledge or solve problems.
KS5.2 Use appropriate tools strategically. [CCSS.MATH.PRACTICE. MP5]
KS6.1 Generate ideas as a team.
KS6.2 Demonstrate teamwork through effective communication.
KS6.3 Demonstrate flexibility and adaptability.
KS7.1 Document work in an organized notebook.
KS7.2 Explain findings and justify evidence-based conclusions with others.
KS7.3 Present data and information accurately and effectively.
KS8.1 Engage in and maintain positive interactions and relationships with other children and adults.
KS8.2 Value and credit the contributions of others.
KS8.3 Recognize that one's behavior impacts those around them.

## Preparation

- Review the Evidence (Stage 2) and Learning Plan (Stage 3) section of the **Curriculum Framework**. Use this tool to plan how you will formatively and summatively assess students throughout this activity.
- Review the **Additional Instructional Resources**. This list includes books that offer diverse perspectives that can expand student understanding. Using these resources provides a sense of inclusion and belonging, and helps students make connections if the content is new to them.

## Activity 2: Create a Toy

**80 minutes**

- In Activity 2: Create a Toy, students work collaboratively with a partner using engineering skills to design, sketch, and build a model of a toy using VEX IQ components. The toy model does not need to be a working, testable prototype, but it should show the group's idea for the design. Students use previous knowledge and experience with different kinds of toys to design a toy that has at least one moving part. For this activity students do **NOT** use motors, sensors, remote controls, or robotic brains.
- The teacher instructs students to access Activity 2: Create a Toy using the curriculum course on their devices. The introduction section of this activity can be used to set the stage for hands-on experience.
- The teacher introduces the criteria and constraints for the toy model using the chart found in the procedures.
- Students follow the procedures for Activity 2. The Launch Log is used for sketches and responses to conclusion questions. As directed in the procedures, students decide how to present the model to the class.
- The teacher directs the presentation of models and conducts a discussion.
    - Did your final model look like your sketch? Why or why not?
    - What can you do to improve your model?
    - How did you contribute to the success of your team's design?
    - How did your team members contribute to the success of the design?

## Conclusion Questions Answer Key

1. How did the criteria and constraints for the toy impact your design?

   Student responses will vary.

2. If you could add other materials to your toy besides the VEX IQ parts, what would you add? How would this improve your toy?

   Student responses will vary.

3. When designing a toy, toy designers must consider the age of the children who will play with it. Do you think children of all ages would be interested in playing with your toy? Why do you think that?

   Student responses will vary.

Activity 3

# Inputs and Outputs

Teacher Resources

View Student Course

## EQUIPMENT

The list below is based on a class of 30 students.

**Note:** The Robotics and Automation module does not have a full or refill classroom kit.

| Not Included in Equipment Kit | Device Applications |
|---|---|
| • Digital devices<br>• Launch Logs<br>• VEX® IQ Robot Design Kits (1 per group) | • Inkling<br>• Internet browser for Fusion 360 links |

## RESOURCES

- Inputs and Outputs Worksheet
- Inputs and Outputs Worksheet Answer Key
- PLTW VEX IQ Robot Design Kit Contents V1
- PLTW VEX IQ Robot Design Kit Contents V2
- VEX IQ Equipment List - Testbed
- VEX IQ Troubleshooting Flowchart For PLTW Controller & Controller Battery
- How to Access VEX IQ Assembly Instructions

## ESSENTIAL QUESTIONS

EQ

EQ1 How can automation and robotics be used to protect the Earth's resources and environment?
EQ2 How can the engineering design process be applied in daily life?

## LEARNING OBJECTIVES

LO

LO1.1 Follow a step-by-step method to solve a problem.
LO1.2 Use scientific reasoning to ask questions, make observations, and investigate ideas to acquire knowledge and solve problems.
LO2.1 Understand that events have causes that generate observable patterns.
LO2.2 Understand that a system is an organized group of related objects or components and that models can be used for understanding the and predicting the behavior of systems.
LO4.2 Analyze how sensors provide input to automated and robotic systems which can be used to adjust the behavior of outputs.
LO5 Apply mathematical thinking to solve problems.
LO6 Collaborate effectively on a diverse and multi-disciplinary team.
LO7 Communicate effectively for specific purposes using the appropriate platform, tool, format, or digital media.
LO8 Practice ethical behavior in all settings.

## KNOWLEDGE AND SKILLS

KS

| | |
|---|---|
| KS1.1.5 | Evaluate a model solution through observations and/or measurements and consider what revisions to the initial model are needed. |
| KS1.2.1 | Ask and identify questions to gain knowledge or solve problems. |
| KS1.2.2 | Make observations to draw conclusions of phenomena. |
| KS1.2.3 | Analyze models as an explanation of phenomena. |
| KS1.2.4 | Understand that science findings are limited to questions that can be answered with evidence. |
| KS2.1.1 | Identify cause and effect relationships. |
| KS2.1.2 | Use cause and effect relationships to explain change. |
| KS2.1.3 | Analyze data to look for patterns or to test whether data are consistent with an initial prediction. |
| KS2.2.1 | Understand that system is a group of related parts that make up a whole. |
| KS2.2.2 | Recognize that a system can carry out functions that its individual parts cannot do alone. |
| KS2.2.3 | Describe a system using its components and their interactions. |
| KS4.2.1 | Identify inputs and outputs within a robotic system. |
| KS4.2.2 | Design a control system to use sensor feedback to make decisions. |
| KS5.2 | Use appropriate tools strategically. [CCSS.MATH.PRACTICE. MP5] |
| KS5.3 | Attend to precision. [CCSS.MATH.PRACTICE.MP6] |
| KS6.2 | Demonstrate teamwork through effective communication. |
| KS6.3 | Demonstrate flexibility and adaptability. |
| KS7.1 | Document work in an organized notebook. |
| KS7.2 | Explain findings and justify evidence-based conclusions with others. |
| KS7.3 | Present data and information accurately and effectively. |
| KS8.1 | Engage in and maintain positive interactions and relationships with other children and adults. |
| KS8.2 | Value and credit the contributions of others. |
| KS8.3 | Recognize that one's behavior impacts those around them. |

## Preparation

- Review the Evidence (Stage 2) and Learning Plan (Stage 3) section of the **Curriculum Framework**. Use this tool to plan how you will formatively and summatively assess students throughout this activity.
- Review the **Additional Instructional Resources**. This list includes books that offer diverse perspectives that can expand student understanding. Using these resources provides a sense of inclusion and belonging, and helps students make connections if the content is new to them.

## Activity 3: Inputs and Outputs

**100 minutes**

**Note:** There are multiple options available to access the build files required to work with the VEX IQ components. Please refer to the **Introduction to the Module** to determine which option to utilize.

- In Activity 3: Inputs and Outputs, students will gain understanding of a variety of input and output devices, including a motor, bumper switch, touch LED, color sensor, and controller through hands-on experience. The teacher prepares for the activity by creating groups of four students and preparing a printed copy of the Activity 3 Inputs and Outputs Worksheet for each group. The Fusion 360 link will be used to provide building directions for students in this activity. One testbed can be constructed from one VEX IQ Robot Design Kit.

  **Note:** The teacher may choose to provide an equipment list to each group to help students identify the VEX IQ equipment. In the Resources section, you will find a printable parts list for the testbed.

- The teacher reads the fictional story of the friends (Introduction, Part 2 Exploring Robotics). Alternately, the students may read Part 2 individually, in pairs, or small groups.
- The teacher uses the introduction found in Activity 3 to set the stage for this learning experience. Students access this page either through the curriculum course or a printed copy (see above).
- The teacher guides students to complete Part 1 and record their results on the Inputs and Outputs worksheet.
- Students continue working through Parts 2, 3, and 4 in the same manner.
- As students work through this activity, the teacher may discuss each part with individual groups, allowing students to progress at their own pace. Alternately, the teacher may conduct a whole class discussion about each part before assigning the next part of the activity.
- Student responses to the analysis questions can be recorded in the Launch Log.
- As an extension of the learning in this activity, students may reflect on and write about inputs and outputs they think are included in a robot they researched in the previous activity. Students can place a screenshot of the robot into a presentation application on the device and then label possible inputs and outputs as well as the function of each. The teacher may also lead a class discussion prompting students to think about inputs and outputs in common machines such as a microwave, MP3 player, or car.
- Disassemble the testbed when part 2 is completed.

## Conclusion Questions Answer Key

1. Which sensor or sensors could be used to stop a robot in an emergency? Explain your thinking.

   Student responses will vary.

2. Why do you think it is important to test the input and output devices before building a robot?

   Student responses will vary.

3. Now that you have a better understanding of the motors, sensor, and remote control, how would you redesign your toy from Activity 2?

   Student responses will vary.

Project

# Build a Robot

Teacher Resources

View Student Course

## EQUIPMENT

The list below is based on a class of 30 students.

**Note:** The Robotics and Automation module does not have a full or refill classroom kit.

| Not Included in Equipment Kit | Device Applications |
|---|---|
| • Digital devices<br>• Launch Logs<br>• VEX® IQ Robot Design Kits (1 per group)<br>• Colored blocks | • Inkling<br>• Internet browser for Fusion 360 and Robots links |

## RESOURCES

VEX IQ Equipment List - Chassis

How to Access VEX IQ Assembly Instructions

## ESSENTIAL QUESTIONS

EQ

EQ1 How can automation and robotics be used to protect the Earth's resources and environment?

EQ2 How can the engineering design process be applied in daily life?

## LEARNING OBJECTIVES

LO

LO1.1 Follow a step-by-step method to solve a problem.

LO1.2 Use scientific reasoning to ask questions, make observations, and investigate ideas to acquire knowledge and solve problems.

LO2.1 Understand that events have causes that generate observable patterns.

LO2.2 Understand that a system is an organized group of related objects or components and that models can be used for understanding the and predicting the behavior of systems.

LO3 Understand that science ideas can be used to protect humans, Earth's resources, and its environment.

LO4.1 Understand that automation and robotics can be used to complete a task that would cause a safety hazard for humans.

LO4.2 Analyze how sensors provide input to automated and robotic systems which can be used to adjust the behavior of outputs.

LO5 Apply mathematical thinking to solve problems.

LO6 Collaborate effectively on a diverse and multi-disciplinary team.

LO7 Communicate effectively for specific purposes using the appropriate platform, tool, format, or digital media.

LO8 Practice ethical behavior in all settings.

## KNOWLEDGE AND SKILLS

KS

| | |
|---|---|
| KS1.1.1 | Understand what happens at each step of the design process. |
| KS1.1.2 | Define a simple design problem reflecting a need or a want. |
| KS1.1.3 | Brainstorm possible solutions to the problem. |
| KS1.1.4 | Make and use a model to test a design or aspects of a design, and to compare the effectiveness of different design solutions. |
| KS1.1.5 | Evaluate a model solution through observations and/or measurements and consider what revisions to the initial model are needed. |
| KS1.2.1 | Ask and identify questions to gain knowledge or solve problems. |
| KS1.2.2 | Make observations to draw conclusions of phenomena. |
| KS1.2.3 | Analyze models as an explanation of phenomena. |
| KS2.1.1 | Identify cause and effect relationships. |
| KS2.1.2 | Use cause and effect relationships to explain change. |
| KS2.1.3 | Analyze data to look for patterns or to test whether data are consistent with an initial prediction. |
| KS2.2.1 | |
| KS2.2.2 | Recognize that a system can carry out functions that its individual parts cannot do alone. |
| KS2.2.3 | |
| KS3.4 | Understand that engineers improve existing technologies for different reasons. |
| KS4.1.2 | Identify applications of robot technology used to complete tasks. |
| KS4.1.3 | Understand that automated systems control devices with minimal human intervention. |
| KS4.2.2 | Design a control system to use sensor feedback to make decisions. |
| KS4.2.3 | Use motors and sensors to solve robotic problems. |
| KS4.2.4 | Select appropriate tools to strategically solve a robotics problem. |
| KS5.1 | Make sense of problems and persevere in solving them. [CCSS.MATH.PRACTICE.MP1] |
| KS5.2 | Use appropriate tools strategically. [CCSS.MATH.PRACTICE. MP5] |
| KS5.3 | Attend to precision. [CCSS.MATH.PRACTICE.MP6] |
| KS6.1 | Generate ideas as a team. |
| KS6.2 | Demonstrate teamwork through effective communication. |
| KS6.3 | Demonstrate flexibility and adaptability. |
| KS7.1 | Document work in an organized notebook. |
| KS8.1 | Engage in and maintain positive interactions and relationships with other children and adults. |
| KS8.2 | Value and credit the contributions of others. |
| KS8.3 | Recognize that one's behavior impacts those around them. |

## Preparation

- Review the Evidence (Stage 2) and Learning Plan (Stage 3) section of the **Curriculum Framework**. Use this tool to plan how you will formatively and summatively assess students throughout this project.
- Review the **Additional Instructional Resources**. This list includes books that offer diverse perspectives that can expand student understanding. Using these resources provides a sense of inclusion and belonging, and helps students make connections if the content is new to them.

## Project: Build a Robot

**120 minutes**

**Note:** There are multiple options available to access the build files required to work with the VEX IQ components. Please refer to the **Introduction to the Module** to determine which option to utilize.

The teacher will predetermine how students will be grouped for the project. This is a team project with a recommended ratio of 4 students to each VEX IQ kit.

- In this project students will build a remotely operated robot with a variety of input and output devices. Students will build a robot chassis according to a given plan. After they have built and tested the vehicle, they have the opportunity to modify the vehicle to complete the task of collecting blocks and moving them across the floor.
- Students access the Project using the curriculum course on their devices and read the introduction. The teacher guides the students through the procedure section of the project and answers questions as needed.
- Students build the robot chassis using directions found in the Fusion 360 link on their devices. One testbed can be constructed from one VEX IQ Robot Design Kit. After the chassis is built, the teacher guides students to test the driver control program.

  **Note:** The teacher may choose to provide an equipment list to each group to help students identify the VEX IQ equipment. In the Resources section, you will find a printable parts list for the chassis.

- The teacher then directs students to follow the procedures and modify the vehicle to complete the task described. As students work through this process, they record their sketches, responses to questions, and results of testing in their Launch Log.
- Students will solve the problem of moving blocks across a section of floor using the following criteria and constraints:
  - To be successful, the vehicle must move a minimum of three blocks into a collection zone in 2 minutes or less.
  - Students may add additional VEX IQ parts to the vehicle, but they may not remove any parts from the robot.
  - The vehicle must avoid driving over red zones in the field.
  - If your vehicle is stopped in the red zone, you will be required to pick up your vehicle and place it at the start line to continue the trial.
- A field may be created using white paper and red markers or by placing red construction paper along the edges of the path. When the color sensor detects red, the vehicle will turn off as a safety feature.
- The teacher may wish to review the project in the additional professional development resources.
- The teacher leads students to complete the Conclusion Questions either in writing in the Launch Logs or through a class discussion.
- The chassis will be used throughout the remainder of the module and should remain assembled.

## Conclusion Questions Answer Key

1 What part of the design process was the most challenging during this project? Why?

Student responses will vary.

2 How could you use the robot chassis outside of the classroom?

Student responses will vary.

Problem

# Environmental Design Problem

Teacher Resources

View Student Course

## EQUIPMENT

The list below is based on a class of 30 students.

**Note:** The Robotics and Automation module does not have a full or refill classroom kit.

| Not Included in Equipment Kit | Device Applications |
|---|---|
| • Digital devices<br>• Launch Logs<br>• VEX® IQ Robot Design Kits<br>• VEX IQ chassis built in Project 4 Colored blocks<br>• Materials to create the problem site such as masking tape, butcher paper, poster board, or construction paper<br>• Other materials as available such as markers and construction paper | • Inkling<br>• Popplet Lite or ShowMe Interactive Whiteboard<br>• Camera |

## RESOURCES

VEX IQ Challenge Full Field Perimeter & Tiles

Decision Matrix

Summative Assessment

## ESSENTIAL QUESTIONS

EQ

EQ1 How can automation and robotics be used to protect the Earth's resources and environment?

EQ2 How can the engineering design process be applied in daily life?

## LEARNING OBJECTIVES

LO

LO1.1 Follow a step-by-step method to solve a problem.

LO1.2 Use scientific reasoning to ask questions, make observations, and investigate ideas to acquire knowledge and solve problems.

LO2.1 Understand that events have causes that generate observable patterns.

LO2.2 Understand that a system is an organized group of related objects or components and that models can be used for understanding the and predicting the behavior of systems.

LO3 Understand that science ideas can be used to protect humans, Earth's resources, and its environment.

LO4.1 Understand that automation and robotics can be used to complete a task that would cause a safety hazard for humans.

LO4.2 Analyze how sensors provide input to automated and robotic systems which can be used to adjust the behavior of outputs.

LO5 Apply mathematical thinking to solve problems.

LO6 Collaborate effectively on a diverse and multi-disciplinary team.

LO7 Communicate effectively for specific purposes using the appropriate platform, tool, format, or digital media.

LO8 Practice ethical behavior in all settings.

## KNOWLEDGE AND SKILLS

KS

| | |
|---|---|
| KS1.1.1 | Understand what happens at each step of the design process. |
| KS1.1.2 | Define a simple design problem reflecting a need or a want. |
| KS1.1.3 | Brainstorm possible solutions to the problem. |
| KS1.1.4 | Make and use a model to test a design or aspects of a design, and to compare the effectiveness of different design solutions. |
| KS1.1.5 | Evaluate a model solution through observations and/or measurements and consider what revisions to the initial model are needed. |
| KS1.2.1 | Ask and identify questions to gain knowledge or solve problems. |
| KS1.2.2 | Make observations to draw conclusions of phenomena. |
| KS1.2.3 | Analyze models as an explanation of phenomena. |
| KS2.1.1 | Identify cause and effect relationships. |
| KS2.1.2 | Use cause and effect relationships to explain change. |
| KS2.1.3 | Analyze data to look for patterns or to test whether data are consistent with an initial prediction. |
| KS2.2.2 | Recognize that a system can carry out functions that its individual parts cannot do alone. |
| KS3.1 | Explore ways to protect Earth's resources and its environment. |
| KS3.2 | Use science ideas to model how to safely remove hazardous waste during a disaster. |
| KS3.3 | Understand that people's needs and wants change over time |
| KS3.4 | Understand that engineers improve existing technologies for different reasons. |
| KS4.1.2 | Identify applications of robot technology used to complete tasks. |
| KS4.1.3 | Understand that automated systems control devices with minimal human intervention. |
| KS4.1.4 | Demonstrate the functionalities of a vehicle designed to complete a task related to protecting the Earth's resources and environment. |
| KS4.2.2 | Design a control system to use sensor feedback to make decisions. |
| KS4.2.3 | Use motors and sensors to solve robotic problems. |
| KS4.2.4 | Select appropriate tools to strategically solve a robotics problem. |
| KS5.1 | Make sense of problems and persevere in solving them. [CCSS.MATH.PRACTICE.MP1] |
| KS5.2 | Use appropriate tools strategically. [CCSS.MATH.PRACTICE. MP5] |
| KS5.3 | Attend to precision. [CCSS.MATH.PRACTICE.MP6] |
| KS6.1 | Generate ideas as a team. |
| KS6.2 | Demonstrate teamwork through effective communication. |
| KS6.3 | Demonstrate flexibility and adaptability. |
| KS7.1 | Document work in an organized notebook. |
| KS7.2 | Explain findings and justify evidence-based conclusions with others. |
| KS7.3 | Present data and information accurately and effectively. |
| KS8.1 | Engage in and maintain positive interactions and relationships with other children and adults. |
| KS8.2 | Value and credit the contributions of others. |
| KS8.3 | Recognize that one's behavior impacts those around them. |

## Preparation

- Review the Evidence (Stage 2) and Learning Plan (Stage 3) section of the **Curriculum Framework**. Use this tool to plan how you will formatively and summatively assess students throughout this problem.
- Review the **Additional Instructional Resources**. This list includes books that offer diverse perspectives that can expand student understanding. Using these resources provides a sense of inclusion and belonging, and helps students make connections if the content is new to them.
- As students work through the design process to develop a solution, use the Summative Rubric to assess their demonstration of learning. A printable version of the rubric is accessible in the Resources section of **Summative Assessment**. Use the rubric as a guide throughout the process of solving the problem.

## Problem: Environmental Design

**180 minutes**

To prepare for the Problem of this module, the teacher should ensure that all VEX IQ kits have charged batteries. The teacher will predetermine how students will be grouped for the project. Students work collaboratively in groups with a recommended ratio of 4 students to each VEX IQ kit. The teacher will need to gather masking tape and butcher paper, poster board or construction paper, as well as general supplies such as markers. Colored wooden or plastic blocks are also required.

- In this design problem, students are challenged to design, model, and test a mobile robot that can remove hazardous materials (represented by blocks) from a disaster site. Students also design the layout of a disaster site using criteria and constraints presented in the problem. The robot chassis built in the Project will serve as the basic robot design to be modified by the group.
- The teacher reads the fictional story of the friends (Introduction, Part 3 Building a Prototype) and reminds students of the original design problem. Option: Students review the story using the curriculum course on their devices.
- The students then access Environmental Design Problem using the curriculum course on their devices. The teacher leads students through the procedures as a class. The teacher also explains that students document their work in the last five pages of the Launch Log.

> **Note:** Guide students to view the Design Process video before you begin working through the problem.

- Students work through the steps of the design process as described below:

### Ask

a. The teacher guides a discussion asking the students to again consider the problem.
b. The students respond to questions and list the criteria and constraints in their Launch Log.
c. The teacher guides the students as they complete the self-assessment at the end of the Ask section. The students circle one statement in each row.

### Explore

a. The students work through this part of the design process using the guidelines found in the procedures.
b. After completing their sketches, the teacher guides students to complete the self-assessment found at the end of the Explore section of their Launch Log.

### Model

a. The teacher introduces and guides students through the use of a **Decision Matrix** to select the best design. A printed copy of the Decision Matrix is needed for each student. In order to document their work, students cut and paste the matrix into their Launch Log in the Model section.
b. After students have made a decision about the best design, they will follow the plan to modify the robot.
c. Students will use available materials to design the disaster site according to the criteria and constraints stated. The teacher guides the students to complete the self-assessment at the end of the Model section in the Launch Log.

### Evaluate

a. The students design a test to evaluate how the robot performs the required task.
b. Students conduct three trials that are timed for two minutes and document the results in the Launch Log. Use a camera to record the trials.
c. The teacher directs the students to complete the self-assessment at the end of the Evaluate section in the Launch Log.

### Explain

a. The students present their design, evaluation, suggestions for improvement for their prototype. As part of the presentation, students share how their robot helps to protect Earth's resources and environment.
b. The students may use an app such as Popplet Lite or ShowMe Interactive Whiteboard to present their design, an explanation of results, and suggestions for improvement.

- What would you like to do to improve your model? Why do you think this will be a better solution?
- What challenges did you overcome during the design process?
- Explain how your team collaborated and communicated as you worked together.

c. The teacher instructs students to complete the self-assessment at the end of the Explain section in the Launch Log.
d. The teacher leads a discussion of the Conclusion Questions.

> **Optional Extension:** Students test their mobile robot by attempting to complete the task using another group's disaster site.

- The chassis can be left assembled for use in the Robotics and Automation: Challenge module or disassembled.
- Direct students to complete the Robotics and Automation Check for Understanding. You can access a printable version of this assessment in the Resources section of the **Summative Assessment** page.

## Conclusion Questions Answer Key

1 Was your robot able to successfully solve the problem of removing hazardous waste from a site? Support your answer with evidence you recorded in your Launch Log.

Student responses will vary.

2 What changes would you make to improve the design? Why do you think these changes would improve your robot?

Student responses will vary.

3 In this problem, you designed a robot that could remove hazardous items from a "site" you created. How could your ideas be used to solve a problem in your everyday life?

Student responses will vary.

Introduction to the Module

# Robotics and Automation: Challenge

Teacher Resources



**Distance Learning Support**

For information about PLTW's distance learning support and online learning guides, jump to Distance Learning Support in **PLTW Launch Module-specific PD Resources**.

For distance learning support for facilitating this module, jump to **Distance Learning Support: Robotics and Automation: Challenge Teacher Guide**.

## PREFACE

**Time:** 10 instructional hours

This module begins with an exploration of the world of autonomous robots. Students explore the application of autonomous robots in a variety of situations and learn more about a particular type of robot. The activities and project in this module develop skills and knowledge associated with the utilization of computer software to program robots.

The problem for this module is introduced through a fictional story in which the characters are designing an autonomous guided vehicle that can deliver supplies to a specific area in a hospital without being remotely controlled by a person. In this design problem, students work with a group to apply their knowledge of mechanisms, robotics, and programming to design, build, test, and refine a mobile robot that meets a set of design constraints.

## TRANSFER

T

*Students will be able to independently use their learning to ...*

1. Evaluate a problem in a novel situation.
2. Apply a step by step design process to solve a problem.
3. Justify the use of autonomous robots to solve problems.

## UNDERSTANDINGS

U

*Students will understand that ...*

1. Engineers use a step by step approach to look at and solve a problem called the design process.
2. Engineers and designers create new products and technology to meet a need or want that meets specific criteria for success, including constraints on materials, time, and cost.
3. Engineers generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
4. Engineers propose a solution to a design problem after evaluating multiple possible designs.
5. Prototypes can be evaluated and improved upon by a series of fair and controlled tests to identify a product's strengths and limitations.
6. Engineers write down everything they do to document their work, organize their thoughts, and show their steps in an engineering notebook.
7. Engineers share their work with and get feedback from others at many points throughout the design process.
8. Robotic systems are programmed to complete specific tasks with or without human interaction.
9. Automated guided vehicles (AGVs) such as automatic guided carts, mobile robots, and hybrid lift trucks assist humans in a variety of environments and do not require human interaction while the task is being performed.
10. Sensors provide input to automated and robotic systems which can be used to adjust the behavior of outputs in a closed-loop control system.
11. A variety of computer programming languages can be used to control an autonomous robot.
12. Automation and driver control can be combined to solve a design problem.





## KNOWLEDGE — K

*It is expected that students will ...*

- Explain what happens at each step of the design process.
- State questions that engineers may ask when gathering information about a situation people may want to change.
- Identify the differences between invention and innovation.
- Describe the characteristics of automation systems, including automatic guided vehicles.
- Identify inputs and outputs within a robotic system.
- Identify software and hardware within a robotic system.

## SKILLS — S

*It is expected that students will ...*

- Follow a step by step approach to solving a problem.
- Identify specific constraints such as materials, time, or cost that engineers and designers must take into account given a specific design problem.
- Brainstorm and evaluate existing solutions to a design problem.
- Generate multiple solutions to a design problem, taking into account criteria and constraints.
- Use a decision matrix to compare multiple possible solutions to a design problem and select one to develop, taking into account how well each solution meets the criteria and constraints of the problem.
- Plan fair tests in which variables are controlled to identify a product's strengths and limitations.
- Perform fair tests in which variables are controlled to identify a product's strengths and limitations.
- Organize and maintain an engineering notebook to document work.
- Share findings and conclusions with an audience.
- Apply basic commands used to program a robotic system.
- Design a control system to use sensor feedback to make decisions.
- Apply knowledge of mechanisms, robotics, and programming to compete in a design challenge by designing, building, testing, and refining a mobile robot that meets a set of design constraints.

## ESSENTIAL QUESTIONS — EQ

1. How can autonomous robots be used to help people?
2. How can the engineering design process be applied in daily life?

## RESOURCES

- Curriculum Framework
- Connections to Standards
- Fifth Grade Connections to Standards
- Family Letter
- Additional Instructional Resources
- Fifth Grade Curriculum Revisions
- Device Specifications
- Application List

## Preparation

**Note:** In preparation for teaching this module, it is strongly recommended that the teacher read the Robotics and Automation: Challenge Teacher Resources, including the Understandings, Knowledge, and Skills addressed in the module.

### Accessing VEX IQ Component Assembly Instructions

***Using Fusion 360—an alternative, browser-based tool. Note that this does not require the installation of an app.***

*Students may access the links for building with VEX IQ components by selecting the Fusion 360 links in the student procedures. If you are presented with an option to install an app, ignore this and select the Continue in Browser option.*

*If a Fusion 360 link does not work, close the web browser entirely and select the link again to open the Fusion 360 tool.*

***Using a video—if Fusion 360 is unavailable***

*In a situation where the browser cannot be used to view the steps, a video is available in the student course titled Chassis Video Resource. Direct students to use the video only if the app is not accessible.*

**Note:** There are two versions of the PLTW VEX IQ Robot Design Kit. Either kit version may be used to construct the assemblies required for this module. An assembly guide for the VEX IQ field is included in the Resources section of the Project.

Make sure the VEX IQ equipment is prepared for this module, including charging the controllers and batteries. Refer to the VEX IQ Setup with VEXCode IQ Blocks App document, located on the **PLTW Software** page, to ensure that the VEX IQ hardware is up to date and that the VEXcode IQ Blocks initial setup is complete. A Windows® or Mac computer is required to download VEXos. See **https://www.vexrobotics.com/vexiq/resources/vexos** for more information.

For tablet users, it is important that students work on the same tablet each time they use VEXcode IQ Blocks because all of the projects stay on that tablet. Projects cannot be transferred from one tablet to another. The blue, Smart Radios are required to download a program from a tablet to a robot brain. **If you have grey, 900 MHz radio chips, you need to purchase a set of Smart Radios for each robot.**

For Chromebook users, the projects may be saved locally on the device, or students may save the projects on their Google drive.

**Note:** Refer to the **VEX IQ Troubleshooting Flowchart** for PLTW included located on the **PLTW Technical Support** page, for guidance on resolving technical challenges with the VEX IQ hardware. Additional resources are available at the VEX IQ website: **http://www.vexrobotics.com/vexiq**

## Curriculum Framework and Connections to Standards

Before you facilitate this module, review the Curriculum Framework and Connections to Standards documents.

Standards are the foundation for what is taught in a classroom. They outline what students are expected to learn and be able to do as a result of participating in learning experiences. When planning the implementation of any curriculum, it is essential to identify which standards the curriculum addresses and any standards it does not. This offers greater insight into what the curriculum provides your students and any standards that you may need to address beyond the content provided.

For each PLTW Launch module, teachers are provided a curriculum framework document, which offers a three-stage approach to curriculum planning, assessment, and instruction. The framework document offers a big picture view of the module including the desired results of student learning, assessment opportunities that call for evidence of student learning, and an overview of the scaffolded approach to student learning.

Within the desired results of student learning in the curriculum framework, information is included about module connections to the following standards, when applicable:

- Next Generation Science Standards (NGSS)
- Common Core State Standards (CCSS) in English/Language Arts (ELA) and Mathematics
- Computer Science Teachers Association K–12 Computer Science Standards (CSTA)
- International Society for Technology in Education (ISTE)
- National Association for the Education of Young Children (NAEYC) Early Learning Program Standards
- Head Start Early Learning Outcomes Framework

We understand that your state might not align to these bodies of standards. That is why PLTW Launch is designed for flexible implementation. If your state does not address these standards, spend time comparing your state standards to those identified for the module. Remember that PLTW Launch modules can be implemented at any PreK–5 grade level based on your state standards. Also keep in mind that if you implement a module at a different grade level than

indicated, you might need to make modifications to meet the needs of your students.

Exploring this framework resource before you examine the Teacher Guide gives you a high-level understanding of the stages to curriculum planning, assessment, and instruction. You can also determine how the module connects to the required standards for your state. After you have explored the curriculum framework document, you'll be ready to explore the step-by-step instructions in the Teacher Guide.

## Professional Development

### Resources

Before you facilitate the Robotics and Automation: Challenge module, review the professional development resources.

- Access the **Launchpad** to review:
  - Three Dimensional Learning
  - Claims and Evidence
  - The Teacher as Facilitator
  - PLTW Formative Assessment
  - Using PLTW Launch Logs
  - Uncovering and Addressing Misconceptions
  - The APB Instructional Approach
  - Setting the Stage for APB Learning
  - Thinking Like an Engineer
  - Developing Research Skills with Elementary Students
  - The Design Process Song: Version 1
  - The Design Process Song: Version 2
- Access the **Robotics and Automation: Challenge Module-specific PD Resources** to review:
  - Robotics and Automation: Challenge APB Overview
  - Accessing Additional PD Resources

### Questioning Skills

As you facilitate APB learning, asking probing questions is essential. Within each activity, project, and problem throughout this Teacher Guide, you will notice sample prompts to ask your class. The prompts guide you to ask thought-provoking questions, as well as to identify conceptions and misconceptions.

As you work with your students, remember that you are not limited to the prompts provided. The best way to determine the types of questions to ask your students comes from observing and interacting with your students as they engage in the module. This provides formative assessment of students' conceptual development and allows you to uncover and address misconceptions.

Building your questioning skills increases your capacity to facilitate powerful student learning. For more information, review the following professional development resources in the **Launchpad**:

- The Art of Questioning
- Building Your Questioning Skills

## Family and Community Relationships

Family and community relationships are encouraged throughout the module. A **Family Letter** is provided to introduce Project Lead The Way to families, and encourage families to support students' learning of concepts at home. PLTW recommends that you send this letter to families before you begin a module, to let them know what their students will be learning in school.

FAMILY CONNECTION

In the problem, a Family Connection section is identified by this house icon. This section provides activities families can do to support what students are learning. Families can use the log-in information provided in the Family Letter to access the course activities.

## Developing Vocabulary

Vocabulary learning has been found most effective when active engagement with a term goes beyond just knowing the definition. Rather than presented in isolated lessons, vocabulary is introduced within the context of the activities, project, and problem. Viewing the course on a digital device, students have as-needed access to a glossary and interactive flashcards. Each card has an audio component, so students can independently review these words throughout the module.




0:00 / 0:05

## Icon Legend

Throughout the Teacher Guide, the following icons have special meanings.

### Digital Device

The Digital Device icon indicates times when you or your students will use a device for a learning experience.

### Camera

The Camera icon indicates when you or your students will use a camera for a learning experience. There are many camera options. When possible, the best option is for the students to use the camera on their digital device. However, you might need to assign a class photographer to use a digital camera, or you may be the photographer with the camera on your smartphone.

## Additional Instructional Resources

Project Lead The Way understands the importance of introducing literature, music, and rhyme to students. As such, we created **a list of additional resources** specific to this module. These resources are not included in the equipment kit, and they are not covered in the 10 instructional hours of the module. Incorporating the resources is optional, but they offer ways to provide additional engagement with the concepts explored in this module.

## Curriculum Revisions

The Launch curriculum is continuously updated to provide content and instructional resources that are current and based on best practices. Significant revisions to the curriculum implemented since the prior release of Launch are documented in the **Fifth Grade Curriculum Revisions**.

Activity 1

# Why Automation?

Teacher Resources

View Student Course

## EQUIPMENT

The list below is based on 30 students. The equipment lists in the activities, project, and problem are for one student or student group. Please note that additional resources, such as documents and presentations, may need to be accessed from the curriculum course.

**Note:** The Robotics and Automation: Challenge module does not have a full or refill classroom kit.

| Not Included in Equipment Kit | Device Applications |
|---|---|
| • Launch Logs (1 per student)<br>• Digital devices | • Inkling<br>• Internet browser for Robots link<br>• One of the following:<br>  ◦ Popplet Lite<br>  ◦ ShowMe Interactive Whiteboard<br>  ◦ Mindomo |

## RESOURCES

Launch Log Grades 3-5

Introduction to Robotics and Automation: Challenge

## KNOWLEDGE AND SKILLS

KS

*By the end of this activity, students will be able to ...*

- Explain what happens at each step of the design process.
- State questions that engineers may ask when gathering information about a situation people want to change.
- Identify the differences between invention and innovation.
- Describe the characteristics of automation systems, including automatic guided vehicles.

## ESSENTIAL QUESTIONS

EQ

1. How can autonomous robots be used to help people?
2. How can the engineering design process be applied in daily life?

## Activity 1: Why Automation?

**60 minutes**

- The teacher introduces students to the Launch Log as a place to document their work throughout the module. Students take notes as they research, create sketches, and answer conclusion questions in this notebook.
- Students log in to the device application to access the directions for the module.
- As part of the activity, the teacher reads the Robotics and Automation: Challenge Introduction, which is a fictional story that introduces the problem. The Introduction may be accessed in the curriculum course or printed for students.
- After reading the story, students review the first step of the design process by recording questions they have about the problem presented in the story.
- The teacher facilitates a discussion in which students identify the difference between invention and innovation and how this relates to the field of robotics and automation. Teachers may use this opportunity to review what students have learned previously about robotics and automation.
- In Activity 1: Why Automation?, students explore the need for automated robotic systems and cite specific applications currently in use. Students research and compare autonomous robots to identify characteristics that the robots share and characteristics that are unique to each robot.
- In Step 1 of this activity, students brainstorm examples of autonomous robots and document their thinking using Popplet Lite, ShowMe Interactive Whiteboard, or Mindomo. The teacher determines how students share their ideas with the class. This can be done with a class discussion, digital presentation, or another method as determined by the teacher.
- For Step 3 of this activity, students research one example of an autonomous robot. Students record their findings using Popplet Lite, ShowMe Interactive Whiteboard, or Mindomo. Examples of robots that students can research include: AlphaDog, Drive Unit, Pioneer 3, Harvey, and Autonomous Vehicles such as Boss, Google Self-Driving Car, and Stanley.
- The teacher guides students to complete Activity 1: Why Automation? using the Robots website or printed materials to conduct research on robots following the detailed Part 1 Procedure.
  - Suggested website: **https://robots.ieee.org**
  - Suggested printed materials:
    - National Geographic Readers: Robots, by Melissa Stewart
    - DK Eyewitness Books: Robot, by Roger Bridgman
    - TIME for Kids Explorers: Robots, by Mark Shulman
- The teacher guides students to respond to the Conclusion Questions found at the end of Activity 1. The responses can be shared in writing or through class discussion.

Activity 2

# Introduction to Programming

Teacher Resources

View Student Course

## EQUIPMENT

The list below is based on 30 students. The equipment lists in the activities, project, and problem are for one student or student group. Please note that additional resources, such as documents and presentations, may need to be accessed from the curriculum course.

**Note:** The Robotics and Automation: Challenge module does not have a full or refill classroom kit.

| Not Included in Equipment Kit | Device Application |
|---|---|
| • Launch Logs<br>• Digital devices | • Inkling |

## KNOWLEDGE AND SKILLS

KS

*By the end of this activity, students will be able to ...*

- Identify inputs and outputs within a robotic system.
- Identify software and hardware within a robotic system.

## ESSENTIAL QUESTIONS

EQ

1. How can autonomous robots be used to help people?
2. How can the engineering design process be applied in daily life?

## Activity 2: Introduction to Programming

**60 minutes**

- To set the stage for Activity 3, students need to gain understanding about how robots operate. In Activity 1, students explored examples of autonomous robots. Their hands-on work with a robot chassis in the Robotics and Automation module was limited to controlling their robot using a pre-programmed driver control program. This activity is designed to help students understand that robots must be programmed to perform tasks. Communicating what you want a robot to accomplish requires learning to "speak" in a language (code) that robots understand. Guide your students through Activity 2: Introduction to Programming as shown below to introduce the idea of programming a robot.
  1. Students will work in groups of 2 to complete this task.
  2. Have each group write specific directions for safely moving from one point in the classroom to another. Encourage them to be specific. Allow 5-10 minutes to write the directions.
  3. Pair two groups together. Each group takes a turn following the directions of the other group. It is important that students follow the directions exactly as written. They cannot add or subtract steps or turns. They cannot ask or answer questions as they attempt to follow the instructions as written. Students may find themselves unable to finish the "program" because a desk or wall is in the way or a turn was left out of the directions.
  4. After each group has a turn following directions, instruct the two groups to talk about what worked and didn't work in their directions.
  5. Lead a class discussion about this activity. The purpose is to discover that directions needed to be very specific (i.e., Walk forward 5 steps. Stop. Turn right. Walk forward 10 steps, etc.).
  6. Use students' prior experience to introduce the idea of communicating with a robot. Robots can only perform tasks exactly as they are directed. The directions are given to the robot through a **program** that is written in a **code** that the robot understands.
  7. Students may access the glossary to gain initial understanding of these terms. Hands-on experience with these programming terms and understanding will be developed in the activities in this module.

Activity 3

# Input and Output Programming

Teacher Resources

View Student Course

## EQUIPMENT

The list below is based on 30 students. The equipment lists in the activities, project, and problem are for one student or student group. Please note that additional resources, such as documents and presentations, may need to be accessed from the curriculum course.

**Note:** The Robotics and Automation: Challenge module does not have a full or refill classroom kit.

| Not Included in Equipment Kit | Device Applications |
|---|---|
| • Launch Logs<br>• Digital devices<br>• VEX® IQ Robot Design Kit (1 per group)<br>• Rulers (1 per group)<br>• Colored tape (e.g., masking tape)<br>• Windows® or Mac computer (1 per class)<br>• Chair or box | • Inkling<br>• Internet browser for Fusion 360 links<br>• VEXcode IQ |

## RESOURCES

- VEX IQ Equipment List - Chassis
- PLTW VEX IQ Robot Design Kit Contents V1
- PLTW VEX IQ Robot Design Kit Contents V2
- VEX IQ Troubleshooting Flowchart For PLTW
- VEXcode IQ Resources
- Resources at the PLTW Program Software page
- How to Access VEX IQ Assembly Instructions

## KNOWLEDGE AND SKILLS

KS

*By the end of this activity, students will be able to ...*

- Identify inputs and outputs within a robotic system.
- Identify software and hardware within a robotic system.
- Apply basic commands used to program a robotic system.

## ESSENTIAL QUESTIONS

EQ

1. How can autonomous robots be used to help people?
2. How can the engineering design process be applied in daily life?

# Activity 3: Input and Output Programming

**90 minutes**

## Preparation

**Note**: Please ensure you have the latest version of VEXcode IQ (Version 1.0.8 or later) released on 12/20/19. To check which version of VEXcode IQ is installed, you can use the "File Menu -> About".

1. Review the VEX IQ Setup with VEXcode IQ App resource on the **PLTW Software** page.
2. This resource guides you through how to update the firmware on all smart components. Be sure the firmware is up to date before you begin this activity.

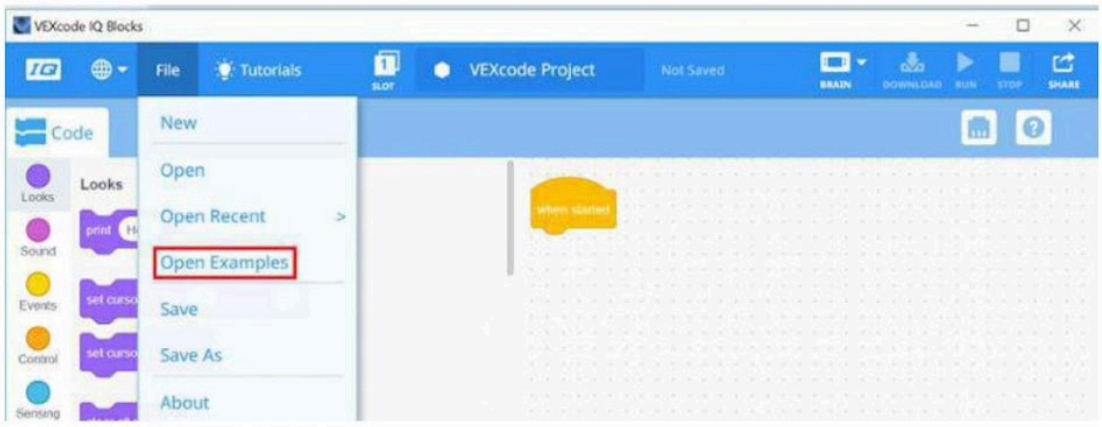
   **Note:** A Windows or Mac computer is required to download VEXos. Please ensure you have the latest version of firmware (Version 2.1.5 or later) released February 2020.

3. Decide how you want to divide the class into groups. Each group needs one VEX IQ Robot Design Kit.
4. Preview the following VEXcode IQ tutorials:
   - Getting Started
   - Moving and Removing Blocks
   - Driving Forward and Backward
   - Turning
   - Using Help
   - Naming and Saving Your Project (select your device)
   - Download and Run a Project
   - Wireless Downloading (tablet users only)
5. Become familiar with the VEXcode IQ interface or the programming environment. Have fun! Create a few sample programs with the given criteria so you can better facilitate this activity with students.

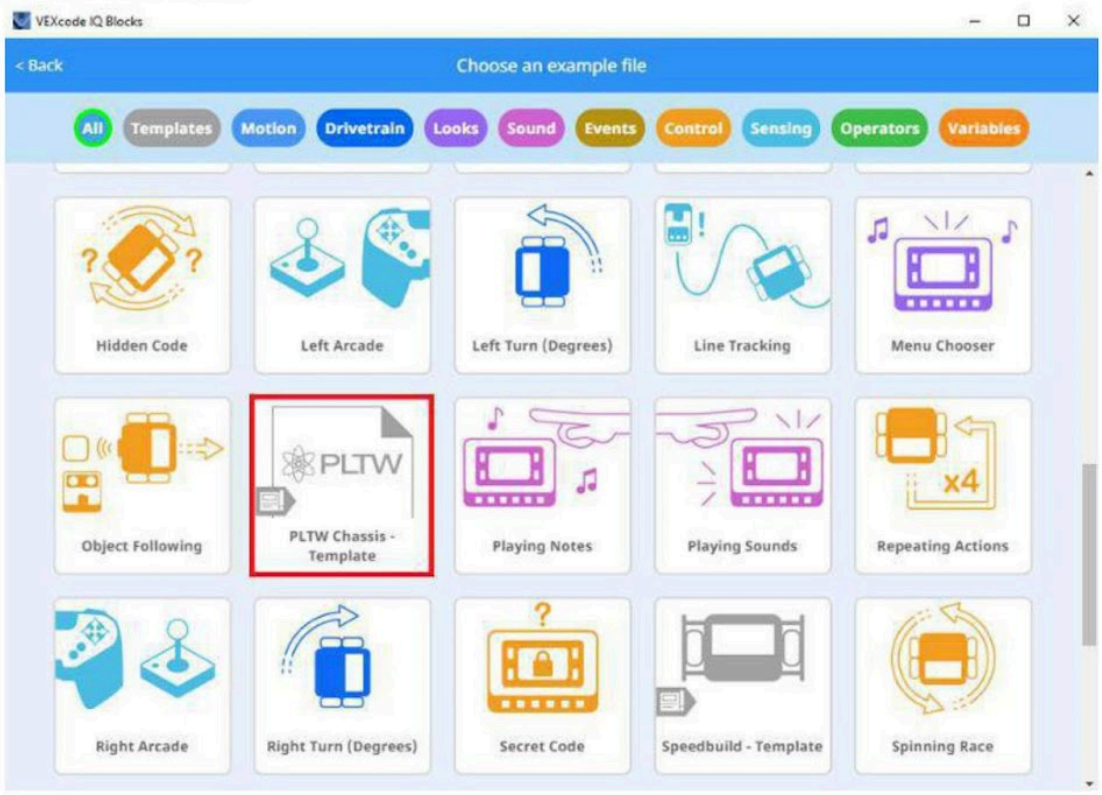
**Notes:**

- There are multiple options available to access the build files required to work with the VEX IQ components. Please refer to the **Introduction to the Module** to determine which option to utilize.
- You may choose to provide an equipment list to each group to help students identify the VEX IQ equipment. In the Resources section, you will find a printable parts list for the chassis.
- The gray, 900 MHz radio chips may only be used with Chromebooks.
- The blue, Smart Radios are required to download a program from a tablet to a robot brain.
- Refer to the **VEX Robotics** website for troubleshooting assistance.

- Guide students to access Activity 3: Input and Output Programming using the device. The introduction section of this activity can be used to set the stage for hands-on experience.
- You may choose to take pictures and record video. You might witness the spark that inspires a student to continue on to become a successful programmer.
- The kit contents for the Robot Design Kits Version 1 and Version 2 are available for reference.
- Guide students to work in a small group to build the robot chassis.
- Have each group open the VEXcode IQ application.
- Guide students to configure their robot.
  - Select **File**. Then click **Open Examples**.




- Select **PLTW Chassis - Template**.




**Note:** The PLTW Chassis - Template includes two Smart Motors, a Color Sensor, and a Touch LED. This template matches the PLTW robot. If desired, students may configure the robot through the **Devices** window following these steps:

- Click on the **Devices** button.
- Select **Drivetrain**.
  - Select Port 1 for the left motor.
  - Select Port 6 for the right motor.
  - Uncheck the box next to "Gyro".
  - Click **Done**.
- Click **Add a device**.
  - Click **Touch LED**.
  - Select Port 3.
  - Click **Done**.
- Click **Add a device**.
  - Click **Color**.
  - Select Port 2.
  - Click **Done**.

- Establish a consistent naming format for all student groups to use. This is very important when using one classroom-wide account. A recommendation is G1A3, which is short for Group 1 Activity 3. Consider posting this in your classroom until students form the habit of using the correct file name.
- To provide a guided learning experience, direct students to interact with a few of the short tutorials:
  - Naming and Saving Your Project
    - Encourage students to save their projects frequently. This avoids the loss of valuable work.
  - Getting Started
  - Driving Forward and Backward
  - Turning

To view the tutorials, guide students to select **Tutorials** on the menu bar.

> **Notes**
>
> - These tutorials are interactive.
> - Encourage students to view the videos first. Then, have them use the steps to drag out code blocks and test the code.
> - Remind the students to test their code incrementally (in small pieces) as they build their programs. Waiting until the program is complete to test it, makes it difficult for students to debug issues in their code and may cause frustration.
> - Students can refer to these tutorials at any time throughout the module.

- Allow students about 15 minutes to program the robot to:
  - Drive forward
  - Drive backward
  - Drive forward and backward a specific distance
  - Turn right
  - Turn left
- Students need to download their program to the robot brain to execute it. Have students view the Download and Run a Project (Chromebook users) or the Wireless Downloading (tablet users) tutorial.
- During this time, walk around and view student progress on the basic understanding of the programming environment.
- At the end of this time, have students share what they learned with the class. Display the programs with a projector so all students can view them. Guide students to discuss which blocks they chose to get their robot to move.
- Challenge students to program their robot to drive in a square. Place a chair or box in an open area of the classroom. Guide students to work together to write a program for their robot to move around the object.
- Have students share their programs with the class. Display the programs with a projector so all students can view them. Guide students to discuss which blocks they chose to get their robot to move in a square around the object.
- Optional: Create an obstacle course in the classroom. Have students work with their group to program their robot to move throughout the course.
- Guide students to complete the Conclusion Questions in their Launch Log, or lead a discussion of the Conclusion Questions with the students.
- The chassis will be used throughout the remainder of the module and should remain assembled.

Project

# Programming Challenge

Teacher Resources

View Student Course

## EQUIPMENT

The list below is based on 30 students. The equipment lists in the activities, project, and problem are for one student or student group. Please note that additional resources, such as documents and presentations, may need to be accessed from the curriculum course throughout the module.

**Note:** The Robotics and Automation: Challenge module does not have a full or refill classroom kit.

| Not Included in Equipment Kit | Device Applications |
|---|---|
| • Launch Logs<br>• Digital devices<br>• VEX® IQ PLTW Launch chassis built in Activity 3 (1 per group)<br>• VEX IQ Robot Design Kit, remaining parts (1 per group)<br>• VEX IQ field, configured in 2 half-fields<br>• Blocks, any color (3 per team) | • Inkling<br>• VEXcode IQ |

## RESOURCE

VEX IQ Challenge Full Field Perimeter & Tiles

## KNOWLEDGE AND SKILLS

KS

*By the end of this project, students will be able to ...*

- Apply basic commands used to program a robotic system.
- Design a control system to use sensor feedback to make decisions.

## ESSENTIAL QUESTIONS

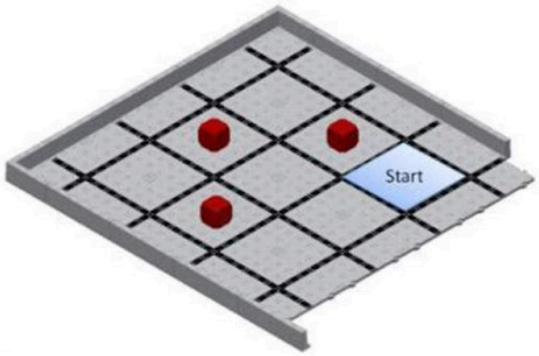
EQ

1. How can autonomous robots be used to help people?
2. How can the engineering design process be applied in daily life?

## Project: Programming Challenge

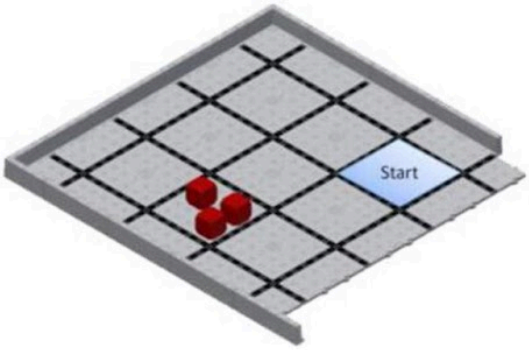
**150 minutes**

- In this project students modify a mobile robot with a variety of input and output devices and then create a computer program to direct the robot to follow a set of instructions.
- Students access Project: Programming Challenge using their devices and read the introduction. The teacher guides the students through the procedure section of the project and answers questions as needed.
- The teacher then directs students to work through the project in small groups.
- The standard setup for the Programming Challenge is shown below.

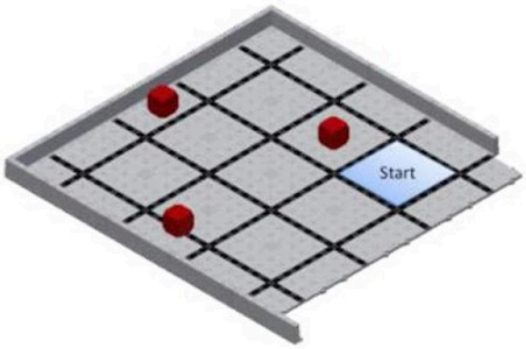



Standard Setup

- Alternate setups are shown below. Setup A is less challenging than the standard arrangement as all the blocks are in one location. Setup B is more challenging than the standard arrangement as the blocks are spread out and closer to the edge of the field.




Alternate Setup A




Alternate Setup B

- As students work through this process, they record their sketches, responses to questions, and results of testing in their Launch Log.

Students should begin their program with the When Touch LED Pressed block.




Allow students to discover this block on their own. If students struggle, guide them to the consider the questions, "What behavior should the robot do?" and "When should the robot do it?" Have the students look through the programming blocks to find a block that answers those questions.

- The teacher leads students to complete the Conclusion Questions either in writing or through a class discussion.
- The chassis will be used throughout the remainder of the module and should remain assembled.

Problem

# Autonomous Vehicle Challenge

Teacher Resources

View Student Course

## EQUIPMENT

The list below is based on 30 students. The equipment lists in the activities, project, and problem are for one student or student group. Please note that additional resources, such as documents and presentations, may need to be accessed from the curriculum course throughout the module.

**Note:** The Robotics and Automation: Challenge module does not have a full or refill classroom kit.

| Not Included in Equipment Kit | Device Applications |
|---|---|
| • Launch Logs<br>• Digital devices<br>• VEX® IQ PLTW Launch chassis built in Activity 3 (1 per group)<br>• VEX IQ Robot Design Kit, remaining parts (1 per group)<br>• VEX IQ Challenge Field<br>• Red, green, and blue blocks | • Inkling<br>• VEXcode IQ<br>• Camera<br>• One of the following:<br>  ◦ Popplet Lite<br>  ◦ ShowMe Interactive Whiteboard<br>  ◦ Mindomo |

## RESOURCES

Decision Matrix

Summative Assessment

## KNOWLEDGE AND SKILLS

KS

*By the end of this problem, students will be able to ...*

- Explain what happens at each step of the design process.
- State questions that engineers may ask when gathering information about a situation people want to change.
- Identify the differences between invention and innovation.
- Describe the characteristics of automation systems, including automatic guided vehicles.
- Identify inputs and outputs within a robotic system.
- Follow a step by step approach to solving a problem.
- Identify specific constraints such as materials, time, or cost that engineers and designers must take into account given a specific design problem.
- Brainstorm and evaluate existing solutions to a design problem.
- Generate multiple solutions to a design problem while taking into account criteria and constraints.
- Use a decision matrix to compare multiple possible solutions to a design problem and select one to develop, taking into account how well each solution meets the criteria and constraints of the problem.
- Plan fair tests in which variables are controlled to identify a product's strengths and limitations.
- Perform fair tests in which variables are controlled to identify a product's strengths and limitations.
- Organize and maintain an engineering notebook to document work.
- Share findings and conclusions with an audience.
- Apply basic commands used to program a robotic system.
- Design a control system to use sensor feedback to make decisions.
- Apply knowledge of mechanisms, robotics, and programming to compete in a design challenge by designing, building, testing, and refining a mobile robot that meets a set of design constraints.

ESSENTIAL QUESTIONS

EQ

1. How can autonomous robots be used to help people?
2. How can the engineering design process be applied in daily life?

## Preparation

As students work through the design process to develop a solution, use the Summative Rubric to assess their demonstration of learning. A printable version of the rubric is accessible in the Resources section of **Summative Assessment**. Use the rubric as a guide throughout the process of solving the problem.

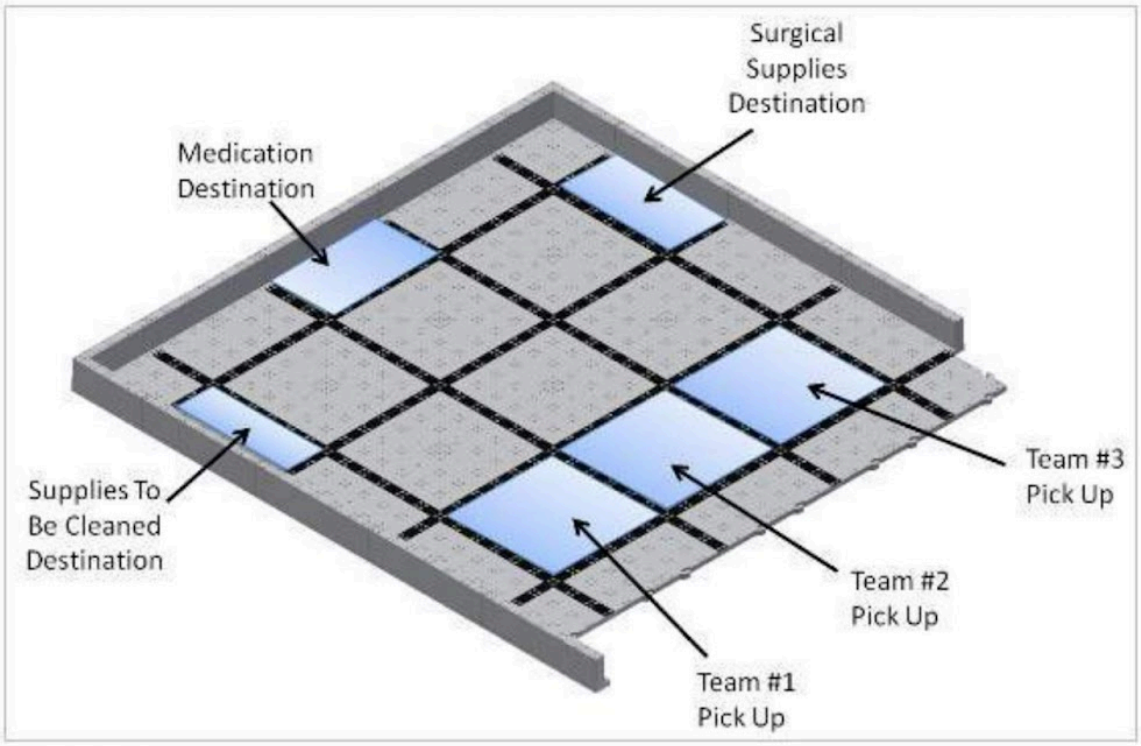
## Problem: Autonomous Vehicle Challenge

**240 minutes**

*To prepare for Problem: Autonomous Vehicle Challenge, the teacher should ensure that all VEX IQ kits have charged batteries. The teacher will predetermine student groups for the problem. Students work collaboratively in groups with a recommended ratio of 4 students to each VEX IQ kit.*

*Students have an opportunity to build on a foundation of programming knowledge and skills. The **VEX IQ Curriculum** can be used to supplement the PLTW Launch curriculum to meet student needs.*

*The teacher can set up the field based on classroom needs. Below is an example of a field configuration.*




Example Field Configuration

- In this design problem, students are challenged to use their knowledge of the VEX IQ platform and programming software to build a fully autonomous robot.
- The teacher reads the fictional story of the friends to remind students of the original design problem of creating an AGV to deliver supplies in a hospital.
- The students then access the Problem: Autonomous Vehicle Challenge using their devices. The teacher leads students through the procedures as a class. The teacher also explains that students document their work in the last five pages of the Launch Log.
- Students work through the steps of the design process as described below. Optional: Guide students to view the Design Process video before you begin working through the problem.

**Ask**

a. The teacher guides a discussion asking the students to again consider the problem.
b. The students respond to questions and list the criteria and constraints in their Launch Log.
c. The teacher guides the students as they complete the self-assessment at the end of the Ask section. The students circle one statement in each row.

**Explore**

a. The students work through this part of the design process using the guidelines found in the procedures.

b. After completing their sketches, the teacher guides students to complete the self-assessment found at the end of the Explore section of their Launch Log.

**Model**

a. The teacher introduces and guides students through the use of a Decision Matrix to select the best design. Each student will need a printed copy of the Decision Matrix. In order to document their work, students cut and paste the matrix into their Launch Log in the Model section.
b. After students have made a decision about the best design, they will follow the plan to modify the robot.
c. Students will use available materials to design the robot for the challenge according to the criteria and constraints stated. The teacher guides the students to complete the self-assessment at the end of the Model section in the Launch Log.

**Evaluate**

a. Students conduct trial runs of the hospital delivery system and record results in the Launch Log. The camera app on the device should be used to record the trials.
b. The teacher directs the students to complete the self-assessment at the end of the Evaluate section in the Launch Log.

**Explain**

a. The students present their design, evaluation, and suggestions for improvement for their prototype.
b. The students may use Popplet Lite, ShowMe Interactive Whiteboard, or Mindomo to present their design, an explanation of results, and suggestions for improvement.
c. The teacher instructs students to complete the self-assessment at the end of the Explain section in the Launch Log.
d. The teacher leads a discussion of the Conclusion Questions.

- Students completing this module have a foundation of skills and knowledge which would be valuable in a competition. Consider providing an enhancement opportunity for students by becoming involved in this competition. Information about the VEX IQ Challenge is available at the **RobotEvents.com** website.
- Disassemble the chassis after the Problem is completed.
- Direct students to complete the Robotics and Automation: Challenge Check for Understanding. You can access a printable version of this assessment in the Resources section of the **Summative Assessment** page.





## IEP AND 504 ACCOMMODATIONS AND MODIFICATIONS FOR EARLY CHILDHOOD AND ELEMENTARY SCHOOL STUDENTS:

Large print textbooks
Textbooks for at-home use
Additional time for assignments
Review of directions
Use of mnemonics
Have student restate information
Concrete examples
Adaptive writing utensils
Support auditory presentations with visuals
Use of a study carrel
Assistance in maintaining uncluttered space
Weekly home-school communication tools (notebook, daily log, phone calls or email messages)
Space for movement or breaks
Study sheets and teacher outlines
Extra visual and verbal cues and prompts
Math sheets with highlighted instructions
Graph paper to assist in organizing or lining up math problems
Use of computers and calculators
Books on tape
Graphic organizers
Quiet corner or room to calm down and relax when anxious
Preferential seating
Alteration of the classroom arrangement
Reduction of distractions
Answers to be dictated
Hands-on activities
Use of manipulatives
No penalty for spelling errors or sloppy handwriting
Follow a routine/schedule
Alternate quiet and active time
Teach time management skills
Rest breaks
Verbal and visual cues regarding directions and staying on task
Agenda book and checklists
Adjusted assignment timelines
Visual daily schedule

Varied reinforcement procedures
Immediate feedback
Work-in-progress check
Personalized examples

## TESTING AND ASSESSMENT ACCOMMODATIONS AND MODIFICATIONS:

Answers to be dictated
Frequent rest breaks
Additional time
Oral testing
Untimed tests
Choice of test format (multiple-choice, essay, true-false)
Alternate ways to evaluate (projects or oral presentations instead of written tests)
Accept short answers
Open-book tests
Read test and directions to student
Provide study outline prior to tests
Highlight key directions
Test in alternative site
Use of calculator
Extra credit option
Preview test procedures
Simplified test wording; rephrased test questions and/or directions

## GENERAL ACCOMMODATIONS AND MODIFICATIONS:

Use of alternative books or materials on the topic being studied
Computerized spell-check support
Word bank of choices for answers to test questions
Provision of calculator and/or number line for math tests
Reworded questions in simpler language
Projects instead of written reports
Highlighting important words or phrases in reading assignments
Modified workload or length of assignments/tests
Modified time demands
Modified grades based on IEP

## BEHAVIOR ACCOMMODATIONS MODIFICATIONS:

Breaks between tasks
Cue expected behavior
Daily feedback to student
Have contingency plans
Use de-escalating strategies
Use positive reinforcement
Use proximity/touch control
Use peer supports and mentoring
Model expected behavior by adults
Have parent sign homework
Have parent sign behavior chart
Set and post class rules
Chart progress and maintain data



**SPRINGFIELD PUBLIC SCHOOLS**

ENGAGING STUDENTS • FOSTERING ACHIEVEMENT • CULTIVATING 21ST CENTURY GLOBAL SKILLS

## IEP AND 504 ACCOMODATIONS AND MODIFICATIONS FOR MIDDLE AND HIGH SCHOOL STUDENTS:

Large print textbooks
Textbooks for at-home use
Additional time for assignments
A locker with adapted lock
Review of directions
Review sessions
Use of mnemonics
Have student restate information
Provision of notes or outlines
Concrete examples
Adaptive writing utensils
Support auditory presentations with visuals
Weekly or bi-weekly home-school communication
Space for movement or breaks
Study sheets and teacher outlines
Extra visual and verbal cues and prompts
Lab and math sheets with highlighted instructions
Graph paper to assist in organizing or lining up math problems
Use of tape recorder for lectures
Use of Interactive notebook
Use of a scribe
Use of computers and calculators
Books on tape
Graphic organizers
Quiet corner or room to calm down and relax when anxious
Preferential seating
Alteration of the classroom arrangement
Reduction of distractions
Answers to be dictated
Hands-on activities
Ability to type all assignments
Follow a routine/schedule
Teach time management and organizational skills
Rest breaks
Verbal and visual cues regarding directions and staying on task
Agenda book and checklists
Daily check-in with case manager or special education teacher
Adjusted assignment timelines
Visual daily schedule

Varied reinforcement procedures
Immediate feedback
Work-in-progress check
Personalized examples

## TESTING AND ASSESSMENT ACCOMMODATIONS AND MODIFICATIONS:

Answers to be dictated
Frequent rest breaks
Additional time
Oral testing
Choice of test format (multiple-choice, essay, true-false)
Alternate ways to evaluate (projects or oral presentations instead of written tests)
Accept short answers
Open-book or open-note tests
Read test and directions to student
Provide study guides prior to tests
Highlight key directions
Test in alternative site
Use of calculator
Extra credit option
Pace long-term projects
Preview test procedures
Simplified test wording; rephrased test questions and/or directions

## GENERAL ACCOMMODATIONS AND MODIFICATIONS:

Allow outlining, instead of writing for an essay or major project
Use of alternative books or materials on the topic being studied
Computerized spell-check support
Word bank of choices for answers to test questions
Provision of calculator for math tests
Film or video supplements in place of reading text
Reworded questions in simpler language
Projects instead of written reports
Highlighting important words or phrases in reading assignments
Modified workload or length of assignments/tests
Modified time demands

Pass/no pass option
Modified grades based on IEP

## BEHAVIOR ACCOMMODATIONS FOR STUDENTS:

Breaks between tasks
Cue expected behavior
Daily feedback to student
Have contingency plans
Use de-escalating strategies
Use positive reinforcement
Use proximity/touch control
Use peer supports and mentoring
Model expected behavior by adults
Have parent sign homework
Set and post class rules
Chart progress and maintain data



**SPRINGFIELD PUBLIC SCHOOLS**

ENGAGING STUDENTS • FOSTERING ACHIEVEMENT • CULTIVATING 21ST CENTURY GLOBAL SKILLS

# Accommodations and Modifications for ESL Students

Give tests orally
Give instructions/directions in writing and orally
Assign a peer tutor, same language or English speaking
Allow use of bilingual/translation dictionary
Provide summaries of text or study guides of particular chapters
Allow errors in speaking
Allow errors in writing
Accept writing in first language
Highlight key vocabulary
Reduce amount of work required
Assess comprehension through demonstration or other alternative means (gestures, drawings)
Rephrase questions, directions, and explanations
Reduce multiple choices on assessments
Provide study guides and/ or outlines
Shorten reading assignments
Allow extended time for test/project completion
Use of audio books
Use of graphic organizers
Use reduced text, so that print is not dense
Use visuals/pictures throughout lesson/unit/assignemt
Adapt homework to reflect language proficiency/home support
Adapt homework to reflect home support
Provide hands-on activities and explanations
Allow extended time to answer questions, and permit drawing, as an explanation
Use of translation dictionaries to locate words in the native language
Use anecdotal records and portfolio of work as forms of assessment
Use story retellings to assess comprehension