Springfield Public Schools
Springfield, New Jersey 07081

PLTW Launch
Grade 4

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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Springfield Board of Education
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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

- 4-PS3-1 Use evidence to construct an explanation relating the speed of an object to the energy of that object.
- 4-PS3-2 Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.
- 4-PS3-3 Ask questions and predict outcomes about the changes in energy that occur when objects collide.
- 4-PS3-4 Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.
- 4-PS4-1 Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move.
- 4-PS4-2 Develop a model to describe that light reflecting from objects and entering the eye allows objects to be seen
- 4-PS4-3 Generate and compare multiple solutions that use patterns to transfer information.
- 4-LS1-1 Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.
- 4-LS1-2 Use a model to describe that animals receive different types of information through their senses, process the information in their brain, and respond to the information in different ways.
- 4-ESS1-1 Identify evidence from patterns in rock formations and fossils in rock layers to support an explanation for changes in a landscape over time.
- 4-ESS2-1 Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation.
- 4-ESS2-2 Analyze and interpret data from maps to describe patterns of Earth's features.
- 4-ESS3-1 Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.
- 4-ESS3-2 Generate and compare multiple solutions to reduce the impacts of natural Earth processes and climate change have on humans.
- 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

Asking Questions and Defining Problems

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

- Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships. (4-PS3-3)
- 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)

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.

- Make observations to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution. (4-PS3-2)
- Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon. (4-ESS2-1)
- 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)

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.

- Use evidence (e.g., measurements, observations, patterns) to construct an explanation. (4-PS3-1)
- Apply scientific ideas to solve design problems. (4-PS3-4)
- Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution. (4-PS4-3), (4-ESS3-2)
- Identify the evidence that supports particular points in an explanation. (4-ESS1-1)
- 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)

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 using an analogy, example, or abstract representation to describe a scientific principle. (4-PS4-1)
- Develop a model to describe phenomena. (4-PS4-2)
- Use a model to test interactions concerning the functioning of a natural system. (4-LS1-2)

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).

- Construct an argument with evidence, data, and/or a model. (4- LS1-1)

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.

- Analyze and interpret data to make sense of phenomena using logical reasoning. (4-ESS2-2)

Obtaining, Evaluating, and Communicating Information

Obtaining, evaluating, and communicating information in 3–5 builds on K–2 experiences and progresses to evaluate

the merit and accuracy of ideas and methods.

- Obtain and combine information from books and other reliable media to explain phenomena. (4- ESS3-1)

Disciplinary Core Ideas (DCIs)

PS3.A: Definitions of Energy

- The faster a given object is moving, the more energy it possesses. (4-PS3-1)
- Energy can be moved from place to place by moving objects or through sound, light, or electric currents. (4-PS3-2), (4-PS3-3)

PS3.B: Conservation of Energy and Energy Transfer

- Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced. (4-PS3-2), (4- PS3-3)
- Light also transfers energy from place to place. (4-PS3-2)
- Energy can also be transferred from place to place by electric currents, which can then be used locally to produce motion, sound, heat, or light. The currents may have been produced to begin with by transforming the energy of motion into electrical energy. (4- PS3-2), (4-PS3-4)

PS3.C: Relationship Between Energy and Forces

- When objects collide, the contact forces transfer energy so as to change the objects' motions. (4- PS3-3)

PS3.D: Energy in Chemical Processes and Everyday Life

- The expression "produce energy" typically refers to the conversion of stored energy into a desired form for practical use. (4-PS3-4)

PS4.A: Wave Properties

- Waves, which are regular patterns of motion, can be made in water by disturbing the surface. When waves move across the surface of deep water, the water goes up and down in place; there is no net motion in the direction of the wave except when the water meets a beach. (Note: This grade band endpoint was moved from K–2.) (4-PS4-1)
- Waves of the same type can differ in amplitude (height of the wave) and wavelength (spacing between wave peaks). (4-PS4-1)

PS4.B: Electromagnetic Radiation

- An object can be seen when light reflected from its surface enters the eyes. (4-PS4-2)

PS4.C: Information Technologies and Instrumentation

- Digitized information can be transmitted over long distances without significant degradation. High-tech devices, such as computers or cell phones, can receive and decode information— convert it from digitized form to voice—and vice versa. (4-PS4-3)

LS1.A: Structure and Function

- Plants and animals have both internal and external structures that serve various functions in growth,

survival, behavior, and reproduction. (4-LS1-1)

LS1.D: Information Processing

- Different sense receptors are specialized for particular kinds of information, which may be then processed by the animal's brain. Animals are able to use their perceptions and memories to guide their actions. (4-LS1-2)

ESS1.C: The History of Planet Earth

- Local, regional, and global patterns of rock formations reveal changes over time due to earth forces, such as earthquakes. The presence and location of certain fossil types indicate the order in which rock layers were formed. (4-ESS1-1)

ESS2.A: Earth Materials and Systems

- Rainfall helps to shape the land and affects the types of living things found in a region. Water, ice, wind, living organisms, and gravity break rocks, soils, and sediments into smaller particles and move them around. (4-ESS2- 1)

ESS2.B: Plate Tectonics and LargeScale System Interactions

- The locations of mountain ranges, deep ocean trenches, ocean floor structures, earthquakes, and volcanoes occur in patterns. Most earthquakes and volcanoes occur in bands that are often along the boundaries between continents and oceans. Major mountain chains form inside continents or near their edges. Maps can help locate the different land and water features areas of Earth. (4-ESS2-2)

ESS2.E: Biogeology

- Living things affect the physical characteristics of their regions. (4- ESS2-1)

ESS3.A: Natural Resources

- Energy and fuels that humans use are derived from natural sources, and their use affects the environment in multiple ways. Some resources are renewable over time, and others are not. (4-ESS3- 1)

ESS3.B: Natural Hazards

- A variety of hazards result from natural processes (e.g., earthquakes, tsunamis, volcanic eruptions). Humans cannot eliminate the hazards but can take steps to reduce their impacts. (4- ESS3-2) (Note: This Disciplinary Core Idea can also be found in 3.WC.)

ETS1.A: Defining 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), (secondary to 4-PS3- 4)

ETS1.B: Designing Solutions to Engineering Problems

- 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)
- Testing a solution involves investigating how well it performs under a range of likely conditions. (secondary to 4-ESS3-2)

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), (secondary to 4-PS4-3)

Crosscutting Concepts

Energy and Matter

- Energy can be transferred in various ways and between objects. (4-PS3-1), (4-PS3-2), (4-PS3-3), (4-PS3-4)

Patterns

- Similarities and differences in patterns can be used to sort and classify natural phenomena. (4- PS4-1)
- Similarities and differences in patterns can be used to sort and classify designed products. (4- PS4-3)
- Patterns can be used as evidence to support an explanation. (4-ESS1-1), (4-ESS2- 2)

Cause and Effect

- Cause and effect relationships are routinely identified. (4-PS4-2)
- Cause and effect relationships are routinely identified, tested, and used to explain change. (4-ESS2- 1), (4-ESS3- 2)
- Cause and effect relationships are routinely identified and used to explain change. (4-ESS3-1)

Systems and System Models

- A system can be described in terms of its components and their interactions. (4-LS1-1), (4-LS1-2)

Connections to Engineering, Technology, and Applications of Science

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

- Engineers improve existing technologies or develop new ones. (4-PS3-4)
- Over time, people's needs and wants change, as do their demands for new and improved technologies. (4-ESS3-1)
- Engineers improve existing technologies or develop new ones to increase their benefits, to decrease known risks, and to meet societal demands. (4-ESS3-2), (3-5-ETS1-2)
- People's needs and wants change over time, as do their demands for new and improved technologies. (3-5-ETS1-1)

Connections to Nature of Science Science is a Human Endeavor

- Most scientists and engineers work in teams. (4-PS3-4) Science affects everyday life. (4- PS3-4)

Interdependence of Science, Engineering, and Technology

- Knowledge of relevant scientific concepts and research findings is important in engineering. (4-PS4- 3), (4-ESS3- 1)

Connections to Nature of Science

Scientific Knowledge is Based on Empirical Evidence

- Science findings are based on recognizing patterns. (4-PS4-1)

Scientific Knowledge Assumes an Order and Consistency in Natural Systems

- Science assumes consistent patterns in natural systems. (4- ESS1-1)

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: Human Impact and Natural Disasters

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: Human Impact and Natural Disasters Teacher Guide**.

PREFACE

Time: 10 instructional hours

In this module, students learn about the relationship between humans and the environment. Students begin the module by activating background knowledge about natural resources. They learn how to reduce the impact humans have on the environment and use the design process to create an upcycled project. Then, students investigate natural disasters, specifically earthquakes, to determine their frequency, location, and risks of harm to humans. Students demonstrate their understanding of the challenges posed by natural disasters through the design of emergency preparedness kits.

Applying the skills and knowledge gained throughout the module, students follow the design process to generate a plan of action in response to one of the following problems:

- How do we reduce the human impact on Earth?
- How do we lessen the impact of natural disasters on humans?

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 Assess the impact of human activity on Earth's natural resources.
T4 Analyze the impact of natural disasters on human populations.

ESSENTIAL QUESTIONS

EQ

EQ1 In what ways do human interactions impact Earth?
EQ2 How do natural hazards impact Earth?
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 Natural resources are derived from nature, and their use affects the environment in multiple ways. Some resources are renewable over time, and others are not.
U3 A variety of hazards result from natural processes, such as earthquakes, tsunamis, or volcanic eruptions. Humans cannot eliminate the hazards but can take steps to reduce their impacts.
U4 Natural and human actions are related to environmental challenges.
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.
LO1.3	Obtain, evaluate, and communicate information.
LO2.1	Compare the impact of using renewable versus non-renewable natural resources.
LO2.2	Analyze how populations have used natural resources to survive.
LO3.1	Understand the impact of natural hazards.
LO3.2	Understand humans cannot eliminate natural hazards but can take steps to reduce their impact.
LO4.1	Analyze how human actions impact the environment.
LO4.2	Analyze how Earth processes impact the environment and our communities.
LO5	Apply mathematical thinking to solve problems.
LO6	Collaborate effectively on a diverse and multidisciplinary team.
LO7	Communicate effectively for specific purposes and settings.
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	Evaluate a solution through observations and/or measurements and consider what revisions to the initial solution 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.
KS1.3.1	Obtain and combine information from books and other reliable media to explain phenomena.
KS2.1.1	Develop a basic understanding of how natural resources are formed and how they are obtained.
KS2.1.2	Explain how obtaining and using natural resources impacts Earth.
KS2.1.3	Identify natural resources as renewable or non-renewable.
KS2.1.4	Compare and contrast renewable and non-renewable natural resources.
KS2.2.1	Identify reasons that human populations live in areas that have ample natural resources.
KS2.2.2	Identify examples of natural resources in your community and/or region.
KS3.1.1	Identify examples of natural processes.
KS3.1.2	Identify locations where specific hazards are most likely to occur.
KS3.1.3	Explain how natural hazards can disrupt populations.
KS3.2.1	Explore ways to predict when and where natural hazards will occur.
KS3.2.2	Identify ways that communities prepare for natural hazards.
KS4.1.1	Investigate the impact of human activity on the environment.
KS4.1.2	Identify ways to reduce human impact on the environment.
KS4.2.1	Explain how natural hazards can impact natural resources.
KS4.2.2	Generate solutions that reduce the impact of natural Earth processes.
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]
KS5.3	KS4.3: Model with mathematics. [CCSS.MATH.PRACTICE.MP4]
KS5.4	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.

14

RESOURCES

R

- Curriculum Framework
- Connections to Standards
- Fourth Grade Connections to Standards
- Family Letter
- Additional Instructional Resources
- Fourth 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 Earth: Human Impact and Natural Disasters module, review the professional development resources.

- Access the **Launchpad** to review:
  - Three Dimensional Learning
  - Building Environmental Literacy Through PLTW Launch
  - 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 **Earth: Human Impact and Natural Disasters Module-specific PD Resources** to review:
  - Earth: Human Impact and Natural Disasters APB Overview
  - Earth: Human Impact and Natural Disasters 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 in 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 Earth: Human Impact and Natural Disasters module. To encourage career connections in the classroom, you could invite speakers, such as a conservation officer, forester, fisheries manager, park naturalist, botanist, environmental engineer, meteorologist, or environmental scientist, to talk about the impact of humans and natural disasters on Earth.

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 is 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 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 devices. 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 **Fourth Grade Curriculum Revisions**.

Introduction Story

Career Day

Teacher Resources

View Student Course

RESOURCE

R

Introduction Story: Career Day

Time: 20 Minutes

Introduction

To set the stage for learning, guide students to read the Introduction Story: *Career Day*, 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: *Career Day*. 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 is 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

Natural Resources

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
• *Human Environmental Impact: How We Affect Earth (Humans and Our Planet)* by Ava Sawyer • World map • Map overlays: ◦ Population Density ◦ Natural Resources	• PLTW Launch Logs (1 per student) • Digital devices • Pencils or colored pencils for sketching • Chart paper • Markers • Natural resources, such as: ◦ Wood ◦ Water ◦ Plants ◦ Rocks ◦ Empty water bottle (to represent air)	• Inkling • ShowMe Interactive Whiteboard

RESOURCES

R

Grades 3–5 Launch Log

Additional Instructional Resources

ESSENTIAL QUESTIONS

EQ

EQ1 In what ways do human interactions impact Earth?
EQ2 How do natural hazards impact 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 Compare the impact of using renewable versus non-renewable natural resources.
LO2.2 Analyze how populations have used natural resources to survive.
LO5 Apply mathematical thinking to solve problems.
LO6 Collaborate effectively on a diverse and multidisciplinary team.
LO7 Communicate effectively for specific purposes and settings.
LO8 Practice ethical behavior in all settings.

21

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	Develop a basic understanding of how natural resources are formed and how they are obtained.
KS2.1.2	Explain how obtaining and using natural resources impacts Earth.
KS2.1.3	Identify natural resources as renewable or non-renewable.
KS2.1.4	Compare and contrast renewable and non-renewable natural resources.
KS2.2.1	Identify reasons that human populations live in areas that have ample natural resources.
KS2.2.2	Identify examples of natural resources in your community and/or region.
KS5.2	Reason abstractly and quantitatively. [CCSS.MATH.PRACTICE.MP2]
KS5.3	KS4.3: Model with mathematics. [CCSS.MATH.PRACTICE.MP4]
KS5.4	Use data to highlight or propose cause-and-effect relationships, predict outcomes, or communicate an idea. [CSTA 1B-DA-07]
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.

Preparation

Part 1. Exploring Natural Resources

1. Before you begin Activity 1, read the **Introduction Story: *Career Day*** with students.
2. Gather examples of natural resources for students to use in this activity. Examples include:
   - Wood
   - Water
   - Plants
   - Rocks
   - Empty water bottle (to represent air)
3. Review the **Natural Resources** interactive experience to become familiar with the content. Review the discussion question prompts found in the Procedures.
4. Prepare a piece of chart paper titled "Natural Resources" with one column labeled "Renewable Resources" and one labeled "Non-renewable Resources." Another option is to create a chart using the ShowMe Interactive Whiteboard app and project the chart for students to view.

Natural Resources	
Renewable Resources	Non-renewable Resources

Part 2. Population Density

Review the world map, the natural resources overlay, and the population density overlay. Prepare to facilitate student exploration of the resources.

Part 3. Human Impact on Earth

1. Read the book *Human Environmental Impact: How We Affect Earth (Humans and Our Planet)* to become familiar with the content and to formulate talking points for discussing this book.
2. Gather chart paper and markers for students to create graphic organizers about resources found in your community, state, or region. Alternatively, you may direct students to create a digital graphic organizer using an application on a digital device.
3. Use the links provided in the **Additional Instructional Resources** document to research natural resources. To find resources in your area, search for natural resources maps or reach out to community or state agencies that provide information about resources in your community. Locate sources for student use in building their knowledge of natural resources found in your community.
4. Determine how you will make groups for creating the graphic organizers.

Part 4. Natural Resource Use Affects Earth

1. Prepare a piece of chart paper titled "Natural Resource Use" with one column labeled "Home" and one labeled "School". Divide the columns further into "Object" and "Natural Resource" as shown in the example below. Another option is to create a chart using the ShowMe Interactive Whiteboard app and project the chart for students to view.

Natural Resource Use			
Home		School	
Object	Natural Resource	Object	Natural Resource
		Paper	Wood (or lumber)

> **Note**: Natural resources we use at home and at school are not usually found in their natural state. Be prepared to provide an example object that you can use for students to identify the natural resource(s) used to make the object. See the example in the chart for using paper as an object and allowing students to identify wood as a natural resource used to make paper.

2. Determine a plan for students to record their resource use at home.

Time: 90 Minutes

Introduction

Natural resources are critical for human survival and success. We use them to build, to drink, and to create power and heat. These materials, such as lumber, water, and minerals, are not created by humans but are found in nature. Some, like wind and solar energy, are *renewable*: they never run out. Others, like minerals and natural gas, are *non-renewable*: they have a limited supply. Regardless of renewability, the way humans use resources can have a significant

impact on the environment. How can we use the resources we need without using them up or harming Earth?

In this activity, students explore the differences between renewable and non-renewable resources. They use a map to see how access to natural resources relates to human populations. Then, students learn about how human use of natural resources impacts Earth.

natural resource	Anything produced by Earth that people can use.
non-renewable resource	Resource that cannot be replaced or regrown.
population	The number of organisms living in a certain area.
population density	A measure of the number of organisms living in a certain area.
renewable resource	Resource that can grow again or does not run out.

Possible Student Misconceptions

- **There is an endless supply of Earth's resources.** Once a non-renewable resource, such as coal or natural gas, is used, it cannot be replaced. It is possible to use up all or most non-renewable resources. A renewable resource, such as energy from the sun and wind, can be replaced.
- **With all of humanity's technological advancements, we are no longer dependent upon nature**. Humans use resources that come from nature every day. Food, water, paper, and energy sources are a few examples. Even technology is made from natural resources. For example, cell phones are made from a variety of metals including aluminum, carbon graphite, and silver.

Procedure

Part 1. Exploring Natural Resources

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. Direct students to access the flashcard example as you introduce the term *natural resource*.
5. Guide students to complete a Think-Pair-Share about the following questions to generate background understanding:
   - What is a renewable resource? What are some examples?
   - What is a non-renewable resource? What are some examples?

   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.
6. Display the piece of wood for students.
7. Guide students to make a claim about whether the piece of wood is a renewable or non-renewable resource. Allow students to provide evidence to support their claim. Record student responses on the chart titled "Natural Resources," whether they are correct or incorrect. Repeat the process with the rest of the natural resource examples.

   Note: When leading 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 have seen (or done)..."

   If a student makes a statement about the type of resource 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 what you said?
   - Is there anything that made you think that?

   Students' evidence can be based on their experiences, observations, or ideas they have learned. As you lead discussions, student misconceptions may arise. Be sure to address the misconceptions.
8. Lead a discussion with students about renewable and non-renewable resources.

- Why do you think wood is a _____ resource?
- Why do you think plants are a _____ resource?
- Why do you think water is a _____ resource?
- Why do you think rocks are a _____ resource?
- Why do you think air is a _____ resource?
- Did we identify more renewable or non-renewable resources?
- Which resource do you use most frequently? Why do you think this?

9. Direct students to access the flashcard examples as you introduce the terms *renewable resource* and *non-renewable resource*. Review the claims from the chart about natural resources guiding students to adjust their claims based on the definitions of the terms.

10. Introduce the **Natural Resources** interactive experience. Guide students to work with a partner or small group to view the interactive experience to build an understanding of natural resources. Students can take notes in their Launch Logs while they view the interactive experience.

11. Lead a discussion about the interactive experience.

- What makes a resource renewable?
- What makes a resource non-renewable?
- Were any of the resources unfamiliar or new to you? Which ones?
- How were each of the resources harvested or gathered from Earth?
- Do you think gathering these resources could impact the environment? Explain your thinking.

Part 2. Population Density

12. Direct students to access the flashcard examples as you introduce the vocabulary terms *population* and *population density*.

13. Distribute the world map and the Population Density overlay. Guide students to place the overlay on top of the world map. Lead a discussion about population density.

- What does a population density map show?
- How is population density measured on this map?
- What do the different colors represent on the map?

14. Distribute the Natural Resources overlay. Guide students to replace the population density overlay with the natural resources overlay on top of the world map. Lead a discussion about the map.

- What kinds of natural resources are included on this map?
- What symbols are used to represent each natural resource?
- What other natural resources do you know that are not found on this map?

15. Guide students to place both overlays on top of the world map to draw a conclusion about the relationship between population and natural resources. Remind students to use evidence to support their conclusion.

- Where do you find the greatest population density in North America? In Asia? In Africa?
- For each continent, how does the population density compare with the location of natural resources?
- Do you find areas with a high population density that have fewer natural resources? What impact might this have on the population?
- Which natural resources are located in areas with low population density? Why might this be?

16. Direct students to record their conclusions supported by evidence about population density and location of natural resources in their Launch Logs.

Part 3. Human Impact on Earth

17. Read aloud the book *Human Environmental Impact: How We Affect Earth*. You may choose to use a document viewer to project an image of the book as you read.

18. Lead a discussion about what students learned about human impact on the environment.

- How do humans impact the plants and animals that live in the natural environment?
- How does garbage affect Earth's surface? Atmosphere? Oceans?
- Why are forests important for our planet?
- What kind of fossil fuels are used to power and heat your home? What impact do these fuels make on the environment?
- Which energy source do you think is the best choice for creating power? Support your claim with evidence.
- How can humans reduce their negative impact on Earth?

19 Distribute chart paper and markers. Direct students to work in small groups to create a graphic organizer to brainstorm examples of natural resources found in your community, state, or region. Assign a type of natural resource to each group, such as:

- Wood
- Wind
- Water
- Plants
- Rocks and minerals
- Oil
- Coal
- Soil

Note: Students may use the resources discussed in the book as a reference.

20 Guide students to:

- Include the natural resource as the topic.
- Make a list of ways that the community uses this natural resource.
- Write at least one idea for conserving resources in the area.

21 Direct students to do a gallery walk to observe other groups' graphic organizers. Allow students to add additional ideas to the graphic organizers.

22 Lead a short reflection about what students learned from creating and reviewing the graphic organizers.

- Which natural resources do you think are most abundant in our area? What evidence do you have to support this?
- Which resources do you think are most important to our community? Why do you think this?
- Which resource do you think would be easiest to conserve? Support your answer with evidence.

Part 4. Natural Resource Use

23 Inform students that they will track their own use of natural resources both at home and at school as they consider how the use of natural resources has an impact on Earth. Students will continue to track the use of natural resources throughout the module.

24 Direct students to create a chart titled "Natural Resource Use" in their Launch Logs. Use the model chart you created to provide guidance for students as they create their charts.

25 Model how to fill out an example in each column. Share an example object, such as paper, with students and allow them to identify the natural resource(s) used to make the object.

Note: Students will use the "School" column in Activity 2. They are setting up the chart now so they can look for items at home.

26 Provide guidance for how students will track the use of natural resources at home.

27 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 do you know a resource is renewable or non-renewable?

Student responses should demonstrate an understanding of renewable and non-renewable resources. Responses might include:
A renewable resource does not have a limited supply and can be used over and over again. A non-renewable resource has a limited supply and could eventually be used up. If a material has a limited supply, then it is non-renewable. If it will never run out, then it is renewable.

2 Why do cities and communities seem to develop where there are natural resources?

Student responses should demonstrate an understanding of natural resources. Responses might include:
Natural resources provide things that people need to live, like air and water. They can be used to create things, like plastics and fuel sources. Finally, people use these resources to make money. For example, harvesting and refining resources creates jobs.

3 Why is it important to conserve natural resources?

Student responses should demonstrate an understanding of natural resources. Responses might include:
It is important to conserve resources because non-renewable resources have a limited supply. They could run out. It is also important to conserve renewable resources, like lumber because harvesting them could impact the environment.

Activity 2

Upcycling

Teacher Resources

View Student Course

EQUIPMENT

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

Items in Equipment Kit	Not Included in Equipment Kit	Device Applications
• Index cards	• PLTW Launch Logs (1 per student) • Digital devices • Pencils or colored pencils for sketching • Chart paper • Blank paper • Markers • Assorted materials, such as: ◦ String ◦ Tape ◦ Milk cartons ◦ Plastic bottles ◦ Tissue boxes ◦ Fabric scraps • Natural Resource Use chart from Activity 1	• Inkling • Timer • Camera • Presentation apps, such as: ◦ Popplet Lite ◦ Mindomo ◦ ShowMe Interactive Whiteboard

RESOURCE

R

Additional Instructional Resources

ESSENTIAL QUESTIONS

EQ

EQ1 In what ways do human interactions impact Earth?
EQ2 How do natural hazards impact 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.
LO2.1 Compare the impact of using renewable versus non-renewable natural resources.
LO4.1 Analyze how human actions impact the environment.
LO6 Collaborate effectively on a diverse and multidisciplinary team.
LO7 Communicate effectively for specific purposes and settings.
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	Evaluate a solution through observations and/or measurements and consider what revisions to the initial solution are needed.
KS2.1.2	Explain how obtaining and using natural resources impacts Earth.
KS4.1.2	Identify ways to reduce human impact on the environment.
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.
KS8.1	Engage in and maintain positive interactions and relationships with other children and adults.

Preparation

Professional Development

Before you facilitate the project, access the **Earth: Human Impact and Natural Disasters Module-specific PD Resources** to review Building Your Understanding: Conserving Natural Resources.

Part 1. Using Natural Resources

1. In Activity 1, students set up a chart for tracking the use of natural resources at home and at school. This chart will be revisited throughout the module. In Part 1 of Activity 2, students share what they have tracked thus far at home and then move into an activity to identify the use of resources at school.
2. Plan how you will organize students into groups of four.
3. Review the steps for the round-robin activity in the Procedure section.
4. Students will use the chart titled "Natural Resource Use" that they created in Activity 1. You may opt to also use a classroom chart using the ShowMe Interactive Whiteboard app and project the chart for students to view.

Natural Resource Use	
Home	School

5. Review the photographs of natural resources in the student course.
6. Review content from the previous lesson about natural resources, including examples of how natural resource use impacts the environment.
7. For students to track the use of natural resources, consider allowing time between facilitating Part 1 and Part 2.

Part 2. What Can We Do?

To prepare for facilitation, review the discussion questions and procedures for Part 2.

Part 3. What Is Upcycling?

1. Plan how you will organize the students into small groups (can be the same as in Part 1).
2. Use the links provided in the **Additional Instructional Resources** document to learn more about upcycling and find photographs of upcycled items to share with the class.
3. Before this activity, ask students to bring in items that can be recycled or thrown away. Use the Family Letter in the Introduction to the Module to ask families for donations, such as empty containers (coffee cans, tissue boxes, plastic beverage bottles), or items you would otherwise discard (fabric scraps, leftover ribbon, unused buttons, string).

Time: 120 Minutes

Introduction

Our environment on Earth is affected by waste and how we choose to handle it. The environment consists of everything around us: air, water, land, plants, and animals. Teaching students ways to preserve Earth's *natural resources* can help them take steps to limit the negative human impact on the environment.

In this activity, students analyze their own resource use and brainstorm ways to decrease the use of natural resources. Students follow the *design process* to design, model, and explain an *upcycled* product.

constraint	A limitation or a restriction. Constraints include limits on time, materials, and size.
criteria	Guidelines or rules used to make a decision about something.
design process	A step-by-step way to solve problems.
recycle	To use waste to make a new material.
reduce	To decrease the amount of waste.
reuse	To use materials again and again.
natural resource	Anything produced by Earth that people can use.
upcycle	To create a usable product from waste.

Possible Student Misconceptions

- **Recycling is a waste of time because garbage eventually decomposes**. Most materials do break down over time, but some, like plastic, can take up to 1,000 years to fully decompose in a landfill. This means a plastic water bottle that holds a drink for less than a week can spend several hundred years in a landfill. If the bottle is recycled instead of thrown in the garbage, it can be made into something new.
- **Recycling has no real benefit**. On average, each person throws away about four and a half pounds of garbage each day. When garbage is thrown into the landfill, the energy we used to make it is lost. When garbage is recycled instead, it means fewer products go in the landfill and less energy is used to make new materials.
- **Recycling is too expensive**. A well-run recycling program can be just as cost effective as disposing of the trash. For example, recycling aluminum cans is much cheaper than manufacturing them from raw materials.

Procedure

Part 1. Using Natural Resources

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 review the term *natural resource*.
4. In Activity 1, students created a chart for identifying Natural Resource Use at home and at school. Ask students to share any items they have added to their list for home use of natural resources.
5. Introduce the natural resources round-robin activity. As students work through the activity, move among the groups to listen for responses that help you gauge student understanding and uncover misconceptions. Continuous round-robin strategy:
   - Divide students into groups of four and assign each group a picture of a different natural resource. Natural resources include:
     - Wood
     - Wind
     - Water
     - Rocks and minerals
     - Oil
     - Plants
     - Coal
     - Soil
   - Explain that once the timer starts, students will have two minutes to name as many things as they can that are made with their natural resource. One student from each group will start the conversation, and the conversation will travel clockwise. Each student will name one thing before the next student's turn.
   - The students will go around the circle as many times as possible until the time is called.
6. Ask students to share a few examples of things they named that are made from their natural resource. Lead a discussion to reflect on this activity.

   - What other items do you think are made from this natural resource?
   - Does anyone disagree with any of the group's examples? Provide evidence to support your idea.

7. Direct students to work with their group to search the classroom for items they believe were made with their group's natural resource.
   - Provide each group with index cards, a marker, and tape.
   - For each item the group identifies, they should write the name of the natural resource on an index card and tape it on or near the item. For example, if the students in the wood group identify pencils, they write "wood" on the index card and tape it on or near the pencils.

   > **Note**: Do not remove the index cards until Part 2. Because index cards are made from a natural resource (wood), it is important to consider how to reuse or recycle them.

8. After groups have completed labeling items, gather the students and allow time for sharing their lists of items used at school. You may also record the items on the Natural Resource Use chart for the class.
9. Explain that for the next few days, the class will track how often they use the natural resources they have listed on the chart. Each time students use an item, have them place a tally mark next to the item on the class chart.
10. Direct students to think about items that can be found at home made from their assigned natural resource. For example, if the group is assigned wood, the student will think of items made from wood in their home, like a kitchen table. Allow time for students to add additional items to the "Home" column of their chart.
11. Guide students to work with a partner from a different group and share items from their "Home" lists.

> **Note**: In Part 2 students reflect on the use of resources at home and at school. Consider allowing one or two days between Part 1 and Part 2 for students to collect data about resource use.

Part 2. What Can We Do?

12 Lead a discussion about the data students collected in class and at home.

- What natural resources are used the most at school?
- What natural resources are used the least at school?
- Why do you think that we use _____ the most? Why do you think we use _____ the least?
- What natural resources are found most in our homes? Why do you think this is true?

13 Have students brainstorm ways to reduce the use of the resources that we use most often. Direct them to write these ideas in their Launch Logs.

14 Guide students to refer to their Launch Logs and share some of their ideas for reducing resource use.

15 Lead a discussion about the terms reduce, reuse, and recycle.

- The classroom and cafeteria trash cans are emptied every day. Where do you think this trash goes?

> **Note**: Most trash ends up in a landfill. A sanitary landfill allows garbage to decompose without contaminating the environment. Once in the landfill, garbage decomposes at different rates. Examples:
>
> | | |
> |---|---|
> | Plastic | up to 1,000 years |
> | Disposable diapers | 550 years |
> | Aluminum cans | 80–200 years |
> | Paper | 2–6 weeks |
> | Foam | never |

- What ideas do you have to reduce the amount of waste we throw away each day at school? Direct students to access the flashcard example as you introduce the term *reduce*.
- Have you ever reused a plastic container to store your food or for some other purpose? What other items have you reused rather than throw them away? Direct students to access the flashcard example as you introduce the term *reuse*.
- What are some items that can be recycled? Direct students to access the flashcard example as you introduce the term *recycle*.
- How does our community recycle? How does our school recycle? What items do you recycle at home?
- Have you ever made something from recycled items? What did you make?
- Look at the index cards posted around the classroom. What should we do with them?

> Student responses should demonstrate an understanding of reusing and recycling. Responses might include:
> I think we should reuse the index cards. We could use the back of the index cards to take notes. After both sides are used, we should recycle them.

16 Have students remove the index cards. Gather the cards so they can be reused and then recycled.

Part 3. What Is Upcycling?

17 Direct students to access the flashcard example as you introduce the term *upcycle*.

18 Explain that students will work in groups. They will follow the design process to "upcycle" a used item into a new one.

19 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

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



Design Process video

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

- Why do engineers use the design process? Direct students to access the flashcard example as you review the vocabulary term *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 we look for a solution. Have you ever identified a problem and then looked for a solution? Allow students to share their thoughts.

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

- Guide students to ask questions to make sure they understand the problem.
- Lead a discussion for students to define the problem, "How can we design a useful product that is made from items that would otherwise go in the trash or recycling bin?"
- 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 design uses materials normally discarded or recycled. • The materials are used for a new purpose.	• Time • Available materials

23 Provide time for students to review a few photographs of upcycled items that you provide. For example, a picture of an old ladder turned into a bookshelf or a glass jar turned into a flower vase are upcycled items. Students can also view the photographs in the student course.

24 The next step in the design process is **Explore**.

- Guide students to view the available materials. You can display items on a table for students to observe, or you can hold up the items in front of the class one at a time.
- Have students consider how these materials could be used to create a usable design from materials that might otherwise be discarded.
- Guide students to brainstorm several ideas that may solve the problem.
- Have students use their Launch Logs to sketch ideas for a design using the materials available.

25 Now students are ready to complete the **Model** step.

- Guide the students to work in their small group to share their designs with the group. Direct students to share their sketch and provide evidence for how the design solves the problem.
- Provide guidance as the group works collaboratively to select the design they think will work best for their upcycled item.
- To facilitate the creation of the upcycled items, circle around the room, monitoring group work and asking questions.
- Remind students that their upcycled item needs to follow the criteria and constraints for this solution.
- Have students make a drawing of their final model in their Launch Logs. Students can also use a camera to take a photograph of their upcycled item.

26 The next step in the design process is **Evaluate**.

- Have students answer this question, "Does the design give a new purpose to materials that could have been discarded?"
- Guide them to make changes to their design based on their evaluation.

- Direct students to reflect on the strengths and weaknesses of their design and record them in their Launch Logs.

27 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:
  - The materials the students used to create the upcycled item that otherwise would have become waste
  - An explanation of how the new product can be used
  - A photograph of the new item they created
  - An explanation of how this helps preserve Earth's natural resources
- Provide time for students to share their presentations.
- After all presentations, lead a discussion to allow students to reflect on their solutions. Use the following prompts to lead the reflection:
  - What materials did you choose for your design? Tell me why you chose them.
  - How does your design help preserve Earth's natural resources?
  - What would you like to do to improve your design? Why do you think that will be a better solution?

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

Conclusion Questions Answer Key

1 Picture an empty, metal can. How could you upcycle it? Brainstorm at least two different options. What is the benefit of upcycling?

Student responses should demonstrate an understanding of upcycling. Responses might include:
I might turn an empty, metal can into a pencil or pen holder, a vase, a planter, or a candle holder. The benefit is that upcycled items are not thrown in the trash, and they reduce future waste because new items are not purchased.

2 Imagine there is a landfill that is overflowing. What items do you think are most likely to be found in the landfill? What are some ways that you could reduce the amount of waste being dumped into the landfill?

Student responses should demonstrate an understanding of human impact on Earth. Responses might include:
Items such as glass, plastic, wood, metal, and paper are filling our landfills. We can reduce the amount of waste by recycling discarded materials into new materials. We can reduce the amount of plastic we use each day and take a waste-free lunch to school. We can reuse items such as glass bottles to store items. We can upcycle items to turn them into something new to use at home.

Activity 3

Natural Disasters

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) • Digital devices • Pencils or colored pencils for sketching • Chart paper • Markers • Natural Resource Use chart from Activity 1	• Inkling • Earthquake Hazards • Disaster Master

RESOURCE

R

Additional Instructional Resources

ESSENTIAL QUESTIONS

EQ

EQ1 In what ways do human interactions impact Earth?
EQ2 How do natural hazards impact 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.
LO1.3 Obtain, evaluate, and communicate information.
LO3.1 Understand the impact of natural hazards.
LO3.2 Understand humans cannot eliminate natural hazards but can take steps to reduce their impact.
LO4.2 Analyze how Earth processes impact the environment and our communities.
LO5 Apply mathematical thinking to solve problems.
LO6 Collaborate effectively on a diverse and multidisciplinary team.
LO7 Communicate effectively for specific purposes and settings.
LO8 Practice ethical behavior in all settings.

35

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.
KS1.3.1	Obtain and combine information from books and other reliable media to explain phenomena.
KS3.1.1	Identify examples of natural processes.
KS3.1.2	Identify locations where specific hazards are most likely to occur.
KS3.1.3	Explain how natural hazards can disrupt populations.
KS3.2.1	Explore ways to predict when and where natural hazards will occur.
KS3.2.2	Identify ways that communities prepare for natural hazards.
KS4.2.1	Explain how natural hazards can impact natural resources.
KS5.2	Reason abstractly and quantitatively. [CCSS.MATH.PRACTICE.MP2]
KS5.3	Model with mathematics. [CCSS.MATH.PRACTICE.MP4]
KS5.4	Use data to highlight or propose cause-and-effect relationships, predict outcomes, or communicate an idea. [CSTA 1B-DA-07]
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.

Preparation

Professional Development

Before you facilitate the Activity 3, access the **Launchpad** to review the the professional development resources.

- Developing Research Skills with Elementary Students
- Integrating Technology and Promoting Online Safety
- Staying Safe and Secure! Interactive Experience

Part 1. What Is a Natural Disaster?

1. In this activity, students continue to review the chart created in Activity 1 for tracking use of natural resources at home and at school. Plan for how students will continue to track use of resources as you move through this module.
2. Review the natural processes that cause natural disasters using the resources provided in the **Additional Instructional Resources**.
3. Review the **Natural Disasters** presentation to become familiar with natural disasters, such as landslides, earthquakes, tsunamis, tornadoes, hurricanes, avalanches, floods, and wildfires.
4. Decide how to divide the class into groups, assigning each group a natural disaster to explore.

Part 2. Exploring Earthquake Data

1. Review the United States Geological Survey (**USGS**) earthquake data that students will analyze. The information that follows provides guidance for exploring this website.
   - Select **Earthquakes** to discover information about real-time earthquakes.
     - Explore the interactive map to identify current earthquake activity.
     - Explore **earthquake statistics** for U.S. states. On this page, students will find the total number of earthquakes for their state and the estimated deaths worldwide due to earthquakes. Take time to explore the states assigned to your students. It is also important to explore your own state and surrounding areas to become familiar with the information located on the site.
     - Another way to explore information by states is to use the **Information by State/Territory resource**. Students should select their assigned states to learn more about recent earthquake activity.
   - You may find a wealth of data on earthquake activity by exploring the site on your own. Become familiar with the site to be ready to provide guidance to students in this activity and for those who wish to explore more on their own.
2. In Part 2, the activity focuses on earthquake data. Consider ways to extend this activity by exploring other types of natural disasters. The **Additional Instructional Resources** offer suggestions for resources about natural disasters.

Part 3. Preparing for Disasters

Review the **Disaster Master** interactive experience on the ready.gov/kids website. Develop a plan for how to facilitate student exploration of this asset. For example, if you want students to work in pairs, consider borrowing digital devices from another classroom for Part 3.

Time: 75 Minutes

Introduction

Humans are not the only factor that impacts Earth. *Natural disasters* are major events caused by Earth's natural processes that often cause harm to people and property. While natural disasters are not preventable, humans can take steps to help reduce the risk of damage from natural disasters. For example, humans can closely monitor volcanic activity to provide warnings for *populations* at risk.

In this activity, students learn about various natural disasters and conduct research on earthquakes.

natural disaster	Major event caused by Earth's natural processes that often causes harm to people and property.
natural hazard	A naturally occurring event that can have a negative impact on people or the environment.
natural resource	Anything produced by Earth that people can use.
population	The number of organisms living in a certain area.

Possible Student Misconceptions

- **All earthquakes are a result of volcanoes erupting**. Most earthquakes occur at the boundaries of tectonic plates. There are three types of plate boundaries: convergent, divergent, and transform. Earthquakes may occur at any of these boundaries.
- **Natural disasters are not related to natural phenomena**. The processes that occur in nature make changes to Earth's surface. Natural disasters are not caused by a myth or a legend, but by changes to the atmosphere, the layers of Earth, fault lines, and even Earth's tectonic plates.
- **A few degrees warmer on Earth is not really that much**. With every degree warmer our Earth gets, there are greater impacts on the environment: oceans warm, more of our glaciers and ice caps melt, water levels rise, habitats shrink or grow, and severe weather events increase.
- **Because we are unsure where the next natural disaster will occur, we cannot prepare for them**. Some areas are more susceptible to different natural disasters, and there are many ways to prepare accordingly. Even though modeling natural disasters is challenging, we continue to use science to understand them better and to make better predictions to save people's lives.

Procedure

Part 1. What Is a Natural Disaster?

1. Before students engage in Activity 3, take time to have students review the Natural Resources Use chart in their Launch Logs from Activities 1 and 2.
   - Allow students to share additional uses of natural resources they have used at home. Direct students to access the flashcard example as you review the term *natural resource*.
   - Allow time for students to add tally marks to the chart for resources they have used. Take time to discuss the use of resources at school and at home. The purpose of continuing to review the chart is to provide data for students to consider the use of natural resources at home and school.
   - Guide students to identify patterns they recognize from their data and ways that they might reduce the use of natural resources.

   - What patterns can you identify in the use of resources?
   - What natural resources are being used most? Least? Why do you think this is so?
   - Consider ways that your class could reduce their use of natural resources.

2. Direct students to access Activity 3 in the student course and have them read the Introduction.
3. Have students prepare their PLTW Launch Logs for Activity 3.
4. Direct students to view the **Natural Disasters** presentation. Students may take notes in their Launch Logs while they view the presentation.
5. Lead a discussion about natural disasters.

   - What are the biggest impacts of natural disasters on people? Direct students to access the flashcard example as you introduce the term *natural disaster*.
   - When does a natural hazard become a natural disaster? Direct students to access the flashcard example as you introduce the term *natural hazard*.
   - What impact can natural disasters have on natural resources? What evidence do you have to support this claim?
   - How might humans help to prevent damage to humans and natural resources?

6. Divide students into small groups. Assign each group a natural disaster from the presentation, and direct them to discuss the following questions:

   - How do you think this natural hazard becomes a natural disaster? Why do you think this is true?
   - Could your assigned natural disaster be prevented? Why or why not?
   - How might your assigned natural disaster impact people?
   - How could the impact of your assigned natural disaster be reduced? Support your claim with evidence.

7. Guide students to record their responses in their Launch Logs.
8. Lead a discussion for students to share what they recorded about their group's assigned natural disaster. Guide them to compare and contrast the information.

Part 2. Exploring Earthquake Data

9. Explain that natural disasters are a threat not only to natural resources, but to humans and property. Now, students will consider in detail the impact earthquakes have on humans.
10. Organize students into pairs. Explain that they will be collecting data about earthquake activity in two states.

11 Assign each pair one state with a high occurrence of earthquakes and one state with a low occurrence for comparison.
- High occurrence states include Nevada, Hawaii, Alaska, California, Oklahoma, Idaho, Kansas, and Wyoming.
- Low occurrence states include Florida, Delaware, Georgia, Iowa, Massachusetts, New Jersey, Pennsylvania, and Vermont

12 Direct students to draw a chart in their Launch Logs to record the earthquake data.

State	Most Recent Year of an Earthquake	Total Number of Earthquakes 2010–2015	Number of Deaths Worldwide in 2010

Note: In 2010, an earthquake with a magnitude of 7.0 struck Haiti. This earthquake killed hundreds of thousands of people.

13 Guide students to use the **USGS** website to research and record the following data for their assigned states.
- The most recent year of an earthquake
- The total number of earthquakes from 2010 to 2015
- The number of deaths worldwide due to earthquakes in 2010

14 After students complete their chart, lead a discussion about the data collected from all groups.

- Identify the states that had the greatest number of earthquakes.
- Can earthquakes be prevented? Why or why not?
- What claims can you make about where earthquakes occur and the population? Direct students to access the flashcard example as you review the term *population*.
- What evidence can you use to support your claims?
- How might an earthquake disrupt the land and the people living in the area? Why do you think this?
- What can people who live in these areas do to reduce the impact of earthquakes?

15 Guide students to use the table to look at the population density of states with the highest occurrence of earthquakes. What conclusions can students draw about population density and earthquake occurrences?

Part 3. Preparing for Disasters

16 Direct students to complete the **Disaster Master** interactive experience on the ready.gov/kids website. In this experience, students make decisions related to natural disasters in a game format.

Note: Be sure to remind the students to write down the password at the end of each level. Here are the passwords provided at the end of each level:
- Level 1: Funnel
- Level 2: Eye
- Level 3: Alarm
- Level 4: Sleet
- Level 5: Seismic
- Level 6: Flash

17 Provide time for students to reflect upon what they learned about preparing for natural disasters as they explored the levels of the game.

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

Conclusion Questions Answer Key

1 What dangers do natural hazards pose to cities? What dangers do natural hazards pose to rural areas?

Student responses should demonstrate an understanding of natural hazards. Responses might include:
In cities, buildings and roads might be damaged, the water supply may be threatened, and there may by sanitation issues. In rural areas, people may have difficulty accessing outside resources, and there might be damage to crops and livestock.

2 What steps can humans take to reduce the impact of a natural disaster?

Student responses should demonstrate an understanding of natural disasters. Responses might include:
First, we can educate ourselves about how to be ready for disasters. It is important to be prepared in case of a disaster. This is especially true if you live in an area that is prone to disasters. For example, people in California need to know what to do in case of a wildfire or earthquake. People along the coast need to know what to do in case of a hurricane. Also, we can build structures that better withstand specific disasters.

Project

Preparing for Emergencies

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
• Emergency Kit Cards	• PLTW Launch Logs (1 per student) • Digital devices • Pencils or colored pencils for sketching • Sticky notes • Natural Resource Use chart from Activity 1	• Inkling • Camera • Ready Kids Build a Kit • Presentation app, such as: ◦ Popplet Lite ◦ Mindomo ◦ ShowMe Interactive Whiteboard

ESSENTIAL QUESTIONS

EQ

EQ1 In what ways do human interactions impact Earth?
EQ2 How do natural hazards impact 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.
LO3.1 Understand the impact of natural hazards.
LO3.2 Understand humans cannot eliminate natural hazards but can take steps to reduce their impact.
LO4.1 Analyze how human actions impact the environment.
LO5 Apply mathematical thinking to solve problems.
LO6 Collaborate effectively on a diverse and multidisciplinary team.
LO7 Communicate effectively for specific purposes and settings.
LO8 Practice ethical behavior in all settings.

KNOWLEDGE AND SKILLS

KS

KS1.2.3 Analyze data to look for patterns or to test whether data are consistent with an initial prediction.
KS3.1.3 Explain how natural hazards can disrupt populations.
KS3.2.2 Identify ways that communities prepare for natural hazards.
KS4.1.2 Identify ways to reduce human impact on the environment.
KS5.4 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.

Preparation

Professional Development

Before you facilitate the project, access the **Earth: Human Impact and Natural Disasters Module-specific PD Resources** to review Building Your Understanding: Disaster Relief.

Part 1. Preparing for Natural Disasters

1. To help you facilitate Part 1, explore the **Ready Kids** website.
2. Review **Build a Kit** to understand the materials to include in an emergency preparedness kit.

Part 2. Emergency Preparedness Kit

1. Plan how you will divide students into small groups and assign them one of the following natural disasters:
   - Hurricanes
   - Earthquakes
   - Floods
   - Wildfires
   - Landslides
   - Tsunamis

   > **Note**: Duplicate the natural disasters based upon your class size.

2. Gather the Emergency Kit Cards, one set for each small group. Review how the cards will be used as students complete the project.
3. In the project, students create a virtual emergency preparedness kit. Alternatively, you may decide that students will create actual kits to be distributed for a specific natural disaster relief in your community or across the world.
   - Contact a relief agency to determine the needs for kits and how donations can be made.
   - If you decide to create an actual emergency preparedness kit for a community, consider sending home a letter to collect objects similar to those on the Emergency Kit Cards. You may also involve students to create a list of needs and take leadership in gathering the supplies.
   - Determine how to introduce students to the need for building kits for this situation. Consider inviting a spokesperson from an agency to share the information with students, or locate a video that shares the need.

Time: 75 Minutes

Introduction

Being prepared for an emergency is not just about staying safe during a *natural disaster*. How would you stay safe in the days after a disaster? What would you do if drinking water became contaminated? An emergency preparedness kit with food, water, clothes, and other necessary items can help people in the challenging days following a natural disaster.

In this project, students play a game to gather supplies needed for an emergency. Then, they sort cards to determine the best supplies to pack into an emergency preparedness kit for a specific natural disaster.

natural disaster	Major event caused by Earth's natural processes that often causes harm to people and property.

Possible Student Misconceptions

- **The worst part of a disaster is during the actual event**. Even though the disaster itself can cause a lot of destruction, the days that follow can be very challenging. After a disaster, you might experience an inability to access clean water or electricity. You might be displaced from your home for an extended period.
- **The more items in an emergency preparedness kit, the better**. Although it is important to make sure that you have everything you need, it is also important not to pack too much. In the event of an emergency, you need to be able to quickly locate what you need. It is important to only pack the essentials.

Procedure

Part 1. Preparing for Natural Disasters

1. Allow time to review the Natural Resources Use chart that students have been completing throughout the module. Discuss new items that have been added to their charts and also the tally marks on the use of resources from the class list. Spend time reflecting on the impact of using resources and identify ways that students have been working to reduce their impact on the use of natural resources.
2. Direct students to access the project in the student course and have them read the Introduction.
3. Have students prepare their PLTW Launch Logs for the project.
4. Lead a class discussion to review the impact of natural disasters explored in Activity 3.

   - How can natural disasters impact humans? Direct students to access the flashcard example as you review the vocabulary term *natural disaster*.
   - What are some crises created by natural disasters?
   - How can natural disasters impact the environment?
   - What can humans do to lessen the impact of natural disasters?
   - How can we prepare for natural disasters?

5. Introduce the idea of an emergency preparedness kit.
6. Direct students to access the **Ready Kids Build a Kit** game.
7. Allow time for students to play the game. Guide students to notice items that are recommended from each area of the home.
8. Lead a discussion about the objects used when building the kits.

   - What items did you select from _____ (room)? For example, the bedroom items include clothes, sturdy shoes, underclothes.
   - What items should be in your kits? Justify your thinking.
   - What items did you select that were not suitable for an emergency kit? Why are these not suitable?
   - What items do you think are needed for a _____ (natural disaster)? Why are these items needed?
   - Does the type of natural disaster make a difference in what would be helpful to have in the kit? For example, do you need to have different objects for a hurricane or a wildfire?

Part 2. Emergency Preparedness Kit

9. Ask students to imagine that an emergency preparedness kit company has hired them to prepare an emergency kit for a specific natural disaster. Assign or allow students to select the natural disaster they will address with a kit.
10. Alternatively, determine a local or global need for emergency preparedness kits to provide help for people who have faced or will face a natural disaster. Introduce the need to students. Provide guidance for how students will create the actual emergency preparedness kits.

    Note: If you have collected donations for students to create an actual emergency preparedness kit that can be donated, you can follow the directions below, except have students create the kit with physical items.

11. Distribute one set of Emergency Kit Cards to each group. Direct groups to review the Emergency Kit Cards and decide which objects to include in the emergency preparedness kit for their natural disaster. Encourage students to refer to their learning from Activities 1, 2, and 3 to help build their kits and explain their choices.
    - Remind students that their kits should be as portable as possible, so they want to only include the most useful items.
    - For each item selected, guide groups to discuss why they have chosen the item and how it will be helpful in their disaster.
12. After groups sort their cards, direct them to create a virtual emergency preparedness kit on their devices. The virtual emergency preparedness kit should include a photograph of the object (either found online or a picture taken of the Object Card) and an explanation of how each object would be helpful in their assigned disaster. Students can also find photographs of items that are not on the cards and include them.

    Note: If students are making actual kits, they may use the Emergency Kit Cards to guide their selection of items.

13. After students have completed their virtual (or real) kits, direct students to participate in a gallery walk. Guide students to provide feedback on a sticky note for each group. Feedback can include thoughts on:
    - Other suggested items to include in the kit
    - Items in the kit they believe may not be necessary
    - Items that might be the most important for the kit
14. Lead a discussion about the items the groups included in their emergency preparedness kits and the reason they chose the items.

- Did the importance of items change depending on the disaster? Why do you think this is true?
- Why were some items included in multiple kits?
- What unique needs might a family have when creating their own emergency preparedness kit?

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

Conclusion Questions Answer Key

1 What might happen if you are not prepared for a natural disaster?

Student responses should demonstrate an understanding of the importance of preparing for natural disasters. Responses might include:
If you are not ready for a natural disaster, you could get hurt or killed. You might not be able to get clean water or food. It might be challenging to contact other people or get information.

2 Following a natural disaster, there are many ways you can help a community, even if you are far away. Consider your assigned natural disaster. How could you best help a community after this natural disaster?

Student responses should demonstrate an understanding of how to help after a natural disaster. Responses might include:
There are many things you could do after a natural disaster. You could send money to support a community after a fire or a flood; send food to a community that has lost power; send building materials to a community destroyed by a tornado; send clean water or first-aid supplies to communities affected by most natural disasters.

3 Do you think including more items in a kit is always better? Justify your thinking.

Student responses should demonstrate an understanding of emergency preparedness kits. Responses might include:
A kit with too many items would be hard to manage. For example, a kit with too many items would make it hard to travel if you needed to evacuate. It could also be hard to find what you need if there are too many things in the kit. More items in a kit do not make it better. Having only the necessary items for the natural disaster makes the kit effective.

Problem

Make a Change

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) • Digital devices • Pencils or colored pencils for sketching	• Inkling • Digital product apps, such as: ◦ Video function on device ◦ Popplet Lite ◦ Mindomo ◦ ShowMe Interactive Whiteboard ◦ Quik ◦ TwistedWave

RESOURCES

R

Research Resources

Decision Matrix

Summative Assessment

ESSENTIAL QUESTIONS

EQ

EQ1 In what ways do human interactions impact Earth?

EQ2 How do natural hazards impact 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.

LO1.3 Obtain, evaluate, and communicate information.

LO4.1 Analyze how human actions impact the environment.

LO4.2 Analyze how Earth processes impact the environment and our communities.

LO5 Apply mathematical thinking to solve problems.

LO6 Collaborate effectively on a diverse and multidisciplinary team.

LO7 Communicate effectively for specific purposes and settings.

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	Evaluate a solution through observations and/or measurements and consider what revisions to the initial solution are needed.
KS1.2.1	Ask and identify questions to gain knowledge or solve problems.
KS1.3.1	Obtain and combine information from books and other reliable media to explain phenomena.
KS4.1.1	Investigate the impact of human activity on the environment.
KS4.1.2	Identify ways to reduce human impact on the environment.
KS4.2.1	Explain how natural hazards can impact natural resources.
KS4.2.2	Generate solutions that reduce the impact of natural Earth processes.
KS5.1	Make sense of problems and persevere in solving them. [CCSS.MATH.PRACTICE.MP1]
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.

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 **Earth: Human Impact and Natural Disasters Module-specific PD Resources** course to review Designing an Action Plan.

Part 1. Local Impacts

1. Gather newspaper articles, magazines, or photographs about human impact on Earth in your community.
2. Gather newspaper articles, magazines, or photographs about the impact of natural disasters on your community.

Part 2. The Action Plan

1. As you prepare to facilitate the problem, note that students will create an action plan to either:
   - Reduce human impact on Earth
   - Lessen the impact of natural disasters on humans
2. Review the **Research Resources** and gather books, websites, articles, and other materials that students can use during the Explore step of the design process.
3. As students work through the design process to develop an action plan, 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.
4. Become familiar with the **Decision Matrix**. The decision matrix is a tool that allows students to rate the action plans 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.
5. As an option, you may consider a platform for students to share their action plans beyond the classroom. For example, invite parents or professionals in related careers to listen to the presentations.

Time: 240 Minutes

Introduction

Through the activities and the project, students have developed an understanding of the impact of humans on Earth and the impact of *natural disasters* on humans.

In the problem, students use the *design process* to create an *action plan* to either reduce human impact on Earth or lessen the impact of natural disasters on humans. They present their plan as a podcast, video blog, or another digital media format.

action plan	A detailed strategy that defines the steps to reach a goal.
consequence	Something that happens as a result of a particular action.
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

Part 1. Local Impacts

1. Review the Introduction Story: *Career Day* with students. Remind students that their challenge is to design a solution to either reduce human impact on the environment or to reduce the impact of natural disasters on humans.
2. Direct students to access the problem in the student course and have them read the Introduction.
3. Divide the class into two groups and assign the following questions:
   - Group 1: How does our community's behavior affect the environment around us?

- Group 2: How is our community affected by natural disasters?

4. Direct students to form smaller groups within their assigned group and develop a claim in answer to their question. They should support their claim with evidence drawn from the newspaper articles, magazines, or photographs, notes in their Launch Logs from previous activities, presentations or websites explored in the modules, or other sources that they can find.

5. Create new groups with at least two students from the Group 1 large group and two students from the Group 2 large group. Guide students to take turns presenting their claim and evidence to each other.

6. Lead a discussion about the claims and evidence presented within the groups.

Part 2. The Action Plan

7. Lead a discussion about the design process.

- Why do we use the design process? Direct students to access the flashcard example as you review the vocabulary term *design process*.
- How does the design process help us solve a problem?
- Why is it important to ask questions as you work through the design process? Why do you think that?

8. Explain to the students that they are going to use the design process to create an *action plan* that either reduces human impact on Earth or lessens the impact of a natural disaster on humans. Students will prepare a digital product to share their action plan with their classmates.

9. Direct students to access the flashcard example as you introduce the vocabulary term *action plan*.

10. Students will complete their action plans in a small group. Allow time for groups to select whether they will create an action plan to reduce human impact on Earth or lessen the impact of natural disasters on humans.

11. 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.

12. The first step in the design process is **Ask**.
- Lead 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 do we design an action plan to reduce human impact on Earth?
  - How do we design an action plan to lessen the impact of natural disasters on humans?
- Introduce the criteria and constraints of the action plans. Direct students to access the flashcard examples as you review the vocabulary terms *criteria* and *constraint*.

Reduce Human Impact on Earth	
Criteria	Constraints
The action plan: • Addresses human use of renewable and non-renewable resources • Explains a consequence or result of the human impact • Lists two changes to human behavior to reduce the impact • Is supported by evidence • Is presented in the form of a digital product	• Time • Digital product apps • Available research

Lessen the Impact of Natural Disasters on Humans	
Criteria	Constraints
The action plan: • Focuses on one natural disaster • Explains how the natural disaster happens • Explains the impact of the disaster on humans • Lists two changes to human behavior that will reduce the impact of the disaster • Is supported by evidence • Is presented in the form of a digital product	• Time • Digital product apps • 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?
- 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.

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

- 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.
- For reducing human impact on Earth, questions can include:

  - What human behaviors harm Earth? Are they changing the Earth slowly or quickly?
  - What impact do these human behaviors have on Earth?
  - What evidence do you have of the consequences of this behavior? What data or observations support this?
  - How can we change human behavior to stop future harm to Earth? How have others tried to solve this or similar problems?

- For lessening the impact of a natural disaster on humans, questions can include:

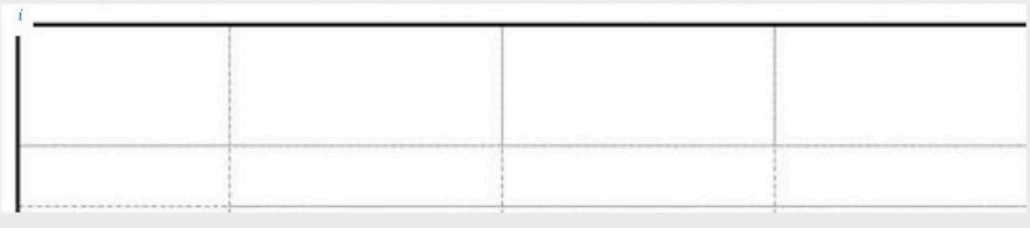
  - What natural disasters cause problems for humans? What disasters are the most common or impact humans the most severely? What data or observation shows this?
  - What impacts do these natural disasters have on humans and the environment?
  - How can we change human behavior to lessen the impact of these natural disasters? How have others tried to solve this or similar problems?

- Guide students to research their topic. See **Research Resources** for research options. You can also direct students to use the local resources that were used in Part 1.
- 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.
- 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.

14 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.

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

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

- How effective are the steps you have chosen to solve the problem?
- Would there be any negative consequences to the steps?
- What else can you do or say to convince others to follow your plan?

- 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.

16 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 to *reduce human impact on Earth* should include:
  - A focus on reducing or stopping human impact on Earth
  - An explanation of how the human impact might happen
  - An explanation of the consequences or results of the human impact
  - A minimum of two changes in human behavior to reduce or stop the human impact
  - Evidence for why this plan will work
- The digital product to *lessen the impact of natural disasters on humans* should include:
  - A focus on one natural disaster
  - An explanation of how the natural disaster happens
  - An explanation of the impact of the disaster on humans
  - A minimum of two changes in human behavior that will lessen the impact of the disaster
  - Evidence for why this plan will work
- Provide time for students to share their digital products.

> **Note**: You may opt to have students present their action plans to parents or professionals who work in related fields of study.

- 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?

- 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.

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

18 Direct students to complete the Earth: Human Impact and Natural Disasters 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 Now that you have heard your peers' recommendations for how to reduce human impact on Earth, what behaviors will you change in your life? Why is it important to make these changes?

Student responses will vary.

2 How can you take what you have learned about the impact of human behavior on Earth and the impact of natural disasters on humans and share it with others outside the classroom? Why is this important?

Student responses will vary.

Introduction to the Module

Earth: Past, Present, and Future

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: Past, Present, and Future Teacher Guide**.

PREFACE

Time: 10 instructional hours

In this module, students explore natural features on Earth. They learn about different landforms and bodies of water. Students apply this knowledge as they identify natural features on a physical map. Students take a deeper look at the origins of landforms as they learn about tectonic plates and plate boundaries. Students recognize patterns in the locations of mountain ranges, earthquake activity, and volcanic activity.

After students establish an understanding of landforms, they examine how landforms have changed over time due to weathering and erosion. Students investigate how mechanical and chemical weathering impacts the Earth, and they identify examples of weathering in their local area. Students use the design process to create a documentary that explains how one of Earth's landforms has been shaped over time.

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



SPRINGFIELD PUBLIC SCHOOLS

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51

Introduction Story

The Amazing Earth

Teacher Resources

View Student Course

RESOURCE

R

Introduction Story: The Amazing Earth

Time: 20 Minutes

Introduction

To set the stage for learning, guide students to read the Introduction Story: *The Amazing Earth*, 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 Amazing Earth*. 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's Natural Features

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
• World map	• PLTW Launch Logs (1 per student) • Digital devices • Pencils or colored pencils for sketching • Chart paper • Markers	• Inkling • Google Earth • ShowMe Interactive Whiteboard

ESSENTIAL QUESTIONS

EQ

EQ1 How has Earth changed over time?
EQ2 Why is Earth constantly changing?
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 Analyze how Earth's landforms have changed over time.
LO4 Apply mathematical thinking to solve problems.
LO5 Collaborate effectively on a diverse and multi-disciplinary team.
LO6 Communicate effectively for specific purposes using the appropriate platform, tool, format, or digital media.
LO7 Practice ethical behavior in all settings.

KNOWLEDGE AND SKILLS

KS

KS1.2.2 Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon.
KS2.1 Identify basic landforms of Earth.
KS2.3 Read and interpret maps to identify patterns of Earth's landforms.
KS4.2 Use appropriate tools strategically. [CCSS.MATH.PRACTICE. MP5]
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.
KS7.1 Engage in and maintain positive interactions and relationships with other children and adults.

Introduction

In this activity, students explore different *natural features* on Earth, such as *mountains*, *hills*, and *oceans*. They make observations and record sketches and notes in their Launch Logs.

As a group, students read a *physical map* to identify natural features found throughout the world. They develop a description of a continent based on the information on a physical map.

Preparation

Part 1. The 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.

bay	A body of water that is partly surrounded by land.
body of water	An area of Earth's surface that is covered in water.
hill	A raised area of land that is smaller than a mountain.
lake	A body of water that is completely surrounded by land.
landform	A natural feature of Earth's surface, such as a hill or a valley.
map	A model that shows where features are located.
map key	The part of a map that explains what the symbols or colors on the map mean.
mountain	An area of land that stands very high above its surroundings.
natural feature	A part of Earth that is not made by people, such as a hill, an ocean, or a stream.
ocean	A large body of salt water that covers most of Earth's surface.
physical map	A map that shows landforms, such as mountains, deserts, and plains.
plain	A large area of flat land with few trees.
plateau	A raised area of land that is flat on top.
river	A large, moving body of water that flows into another body of water.

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 Amazing Earth*** with students.
7. Prepare a piece of chart paper titled, "Earth's Natural Features". Another option is to create the chart using the ShowMe Interactive Whiteboard app and project the chart for students to view.

Earth's Natural Features

8. In this activity, students create a graphic organizer in their Launch Logs to record observations as they explore eight natural features of Earth. If students are not familiar with using graphic organizers, you may consider creating an example to use as you introduce this idea to students.

Possible Student Misconceptions

- **Landforms that we see today have always been on Earth**. Earth is constantly changing. Earth is affected by forces of change due to wind, water, ice, earthquakes, volcanoes, and tectonic plates. The tectonic plate boundaries create new landforms, such as mountains, trenches, and valleys.
- **The ocean floor is flat**. Oceans have many landforms on their floor, such as canyons, plains, and mountains. Many of these landforms are much larger than the ones found on land.

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. Lead a discussion with students about Earth's natural features. Record the responses on the chart paper titled "Earth's Natural Features".

   - What do you think a natural feature is? Direct students to access the flashcard example as you introduce the vocabulary term *natural feature*.
   - What natural features exist in our local area? State? Country? and World?
   - Describe the characteristics of natural features you identified.
   - Natural features are divided into two main categories—landforms and bodies of water. How do you think these two natural features are different? Direct students to access the flashcard examples as you introduce the vocabulary terms *landform* and *body of water*.

5. Guide students to work in a small group to explore eight natural features of Earth. Have students use the search feature in Google Earth to view the Amazon River, Bay of Fundy, Chocolate Hills (Philippines), Great Plains (Kansas), Island in the Sky, Lake Victoria, Matterhorn, and the Pacific Ocean. Have students create a graphic organizer to record their observations of each natural feature.
6. Lead a discussion about the eight natural features.

   - Think of the eight natural features you explored. Which features are landforms? Which features are bodies of water? Use evidence to explain your thinking.
   - How would you define a river? Direct students to access the flashcard example as you introduce the vocabulary term *river*. Which of the natural features is a river? What did you observe about the Amazon River?
   - How would you define a bay? Direct students to access the flashcard example as you introduce the vocabulary term *bay*. Which of the natural features is a bay? How would you describe the Bay of Fundy?
   - How would you define a hill? Direct students to access the flashcard example as you introduce the vocabulary term *hill*. Which of the natural features is a hill? How would you describe the Chocolate Hills?
   - How would you define a plain? Direct students to access the flashcard example as you introduce the vocabulary term *plain*. Which of the natural features is a plain? How would you describe the Great Plains?
   - How would you define a plateau? Direct students to access the flashcard example as you introduce the vocabulary term *plateau*. Which of the natural features is a plateau? What did you observe about Island in the Sky?
   - How would you define a lake? Direct students to access the flashcard example as you introduce the vocabulary term *lake*. Which of the natural features is a lake? How would you describe Lake Victoria?
   - How would you define a mountain? Direct students to access the flashcard example as you introduce the vocabulary term *mountain*. Which of the natural features is a mountain? How would you describe The Matterhorn?
   - How would you define an ocean? What did you notice about the Pacific Ocean? Direct students to access the flashcard example as you introduce the vocabulary term *ocean*. Which of the natural features is an ocean? What surprised you when you zoomed in to the Pacific Ocean?
   - How are these natural features similar? How are they different? What do you think led to the differences in these natural features?

Note: As an extension, allow students to search— with guidance—for other natural features they are interested in viewing on Google Earth.

Part 2. Physical Maps

7. Pose this question to students, "If I needed to locate a natural feature, what tool might I use other than Google Earth?"
8. Direct students to access the flashcard example as you introduce the vocabulary term *map*.
9. Guide students to complete a Think-Pair-Share on the following questions:
   - What are different types of maps you have seen or used?
   - Why do you think there are different types of maps?

> **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.

10. Hand out one physical map of the world to each group. Lead a discussion about the map.

    - What do you notice about this map? Direct students to access the flashcard example as you introduce the vocabulary term *physical map*.
    - What do you think the different colors represent? Why do you think this? Direct students to access the flashcard example as you introduce the vocabulary term *map key*.
    - How is this map different from Google Earth?

11. Assign a continent to each group. Provide support regarding continents as needed for your students. Prompt students to develop a description of the continent based on the information they have on the physical map. Guide them to consider the location and natural features of the continent. Direct students to write this description in their Launch Logs.

> **Note**: If you have eight small groups, assign the oceans to the eighth group.

12. Provide time for students to share what they learned. Lead a discussion about the natural features on a physical map.

    - Are you able to see all the natural features on a physical map? Why do you think this?
    - What natural features are the easiest to identify? Why do you think this?
    - How does your assigned continent compare with the other continents?
    - Where are most of the mountains located? Why do you think this?

13. 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. Identify two natural features found on Earth. How are these natural features similar and how are they different?

   Student responses will vary. Student responses should demonstrate an understanding of natural features.

2. Why are physical maps important?

   Student responses should demonstrate an understanding of physical maps. Responses might include:
   Physical maps are important because they allow us to see some of the natural features on Earth. This type of map provides a more realistic image of Earth, because Earth does not have a completely flat surface.

Activity 2

Tectonic Plates

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
• Moldable sand • World map • Map overlays ◦ Plate Boundaries ◦ Earthquake Activity ◦ Volcanic Activity • Resealable plastic bags (8)	• PLTW Launch Logs (1 per student) • Digital devices • Pencils or colored pencils for sketching	• Inkling • Google Earth • Dynamic Earth Interactive, provided with permission from Annenberg Learner

ESSENTIAL QUESTIONS

EQ

EQ1 How has Earth changed over time?
EQ2 Why is Earth constantly changing?
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 Analyze how Earth's landforms have changed over time.
LO5 Collaborate effectively on a diverse and multi-disciplinary team.
LO6 Communicate effectively for specific purposes using the appropriate platform, tool, format, or digital media.
LO7 Practice ethical behavior in all settings.

KNOWLEDGE AND SKILLS

KS

KS1.2.2 Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon.
KS1.2.3 Analyze data to look for patterns or to test whether data are consistent with an initial prediction.
KS2.3 Read and interpret maps to identify patterns of Earth's landforms.
KS2.4 Develop a basic understanding of tectonic plates.
KS2.5 Understand that there are three types of plate boundaries.
KS2.6 Use a model to replicate interactions between plates.
KS2.7 Explain how mountains are formed.
KS2.8 Identify patterns of where volcanoes and earthquakes occur.
KS4.2 Use appropriate tools strategically. [CCSS.MATH.PRACTICE. MP5]
KS4.3 Attend to precision. [CCSS.MATH.PRACTICE.MP6]
KS4.5 Organize and present collected data visually to highlight relationships and support a claim. [CSTA 1B-DA-06]
KS4.6 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.
KS7.1 Engage in and maintain positive interactions and relationships with other children and adults.

Introduction

Many students think that *earthquakes* and *volcanoes* can occur anywhere on Earth. Most earthquakes and volcanoes occur near a plate *boundary*.

In this activity, students learn about *tectonic plates* and the different type of plate boundaries. They analyze *maps* to draw conclusions about the location of earthquake and volcanic activity.

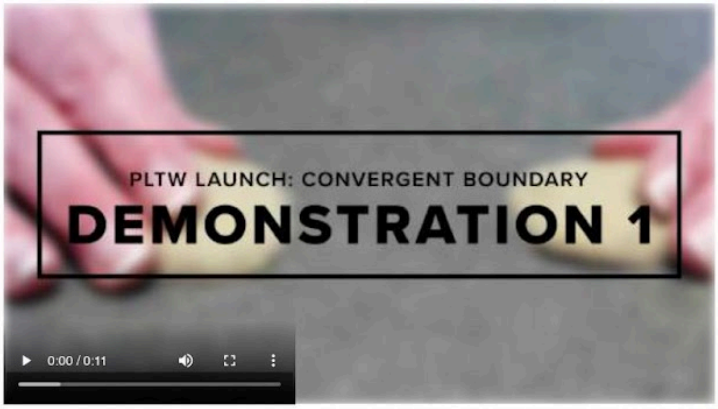
Preparation

Part 1. Exploring Tectonic Plates

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.

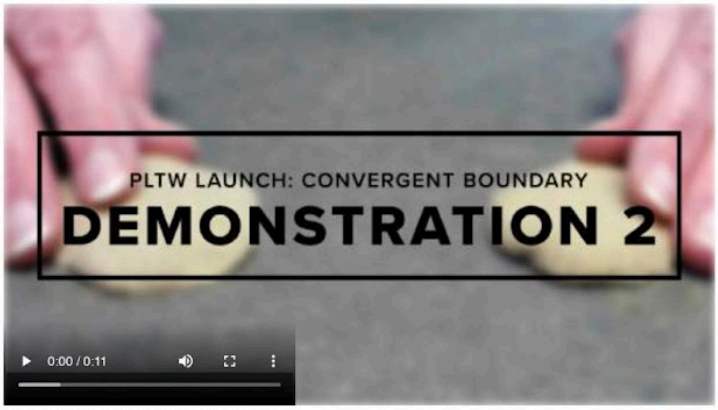
boundary	A real or imaginary line that shows where one area ends and another one begins.
collide	When two things come together with strong force.
convergent boundary	An area where two tectonic plates push together.
divergent boundary	An area where two tectonic plates move apart.
earthquake	A sudden shaking of Earth's surface.
hill	A raised area of land that is smaller than a mountain.
landform	A natural feature of Earth's surface, such as a hill or a valley.
mountain	An area of land that stands very high above its surroundings.
plain	A large area of flat land with few trees.
plateau	A raised area of land that is flat on top.
tectonic plate	A large, moving piece of solid rock.
transform boundary	An area where two tectonic plates slide past each other.
volcano	A landform where molten rock erupts from 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. Divide the moldable sand into eight portions. Place each portion into a resealable plastic bag. Students will use this sand to explore what may happen with tectonic plates.
5. Preview the **Dynamic Earth Interactive** by Annenberg Learner to become familiar with its content. Review the discussion questions in the Procedure.
6. To become familiar with plate boundary demonstrations, form two tectonic plates out of sand. Complete the demonstrations as indicated:
   - Demonstrate convergent boundaries by pushing the sand plates together. Students should observe one plate buckle and move on top of the other plate.



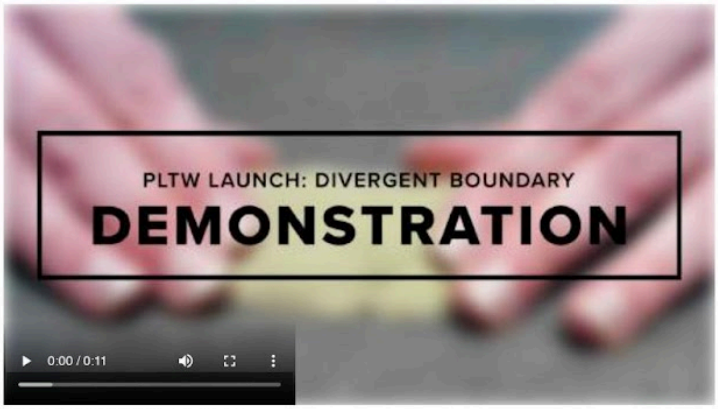
Convergent Boundary Demonstration Part 1 video

   - Demonstrate convergent boundaries by holding one plate in place and pushing the second plate into the first plate. Students should observe one plate buckle and move on top of the other plate.



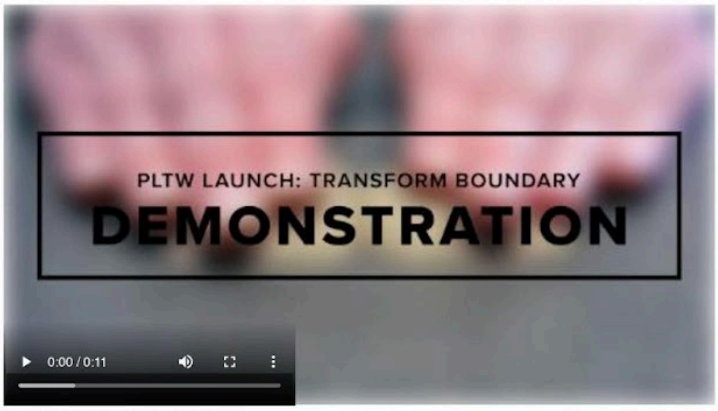
Convergent Boundary Demonstration Part 2 video

- Demonstrate divergent boundaries by placing the sand plates side-by-side and pulling them apart. Students should observe a rift or valley form as the plates pull apart.



Divergent Boundary Demonstration video

- Demonstrate transform boundaries by placing the sand plates side-by-side and rubbing the plates back and forth. Students should observe the plates scrape against each other.



Transform Boundary Demonstration video

7. If your students need additional support with tectonic plates, guide them to explore the **Tectonic Plates** interactive experience.

> **Note**: Allow time for the interactive experience to load completely. When it is fully loaded, students will be able to select each layer of Earth.

Possible Student Misconceptions

- **All earthquakes are a result of volcanoes erupting**. Most earthquakes occur at the boundaries of tectonic plates. There are three types of plate boundaries—convergent, divergent, and transform. Earthquakes may occur at any of these boundaries.
- **The ground opens up during an earthquake**. A crevasse, or open crack, may appear during an earthquake. However, this is likely due to landslides or ground failures. If the ground opened up, there would be no friction at the transform boundary to cause an earthquake.
- **Volcanoes are randomly located across Earth's surface**. Most volcanoes are located on the boundaries of tectonic plates. Seventy-five percent of Earth's volcanoes are in the Ring of Fire in the Pacific Ocean.
- **Volcanoes are only found on land**. Volcanoes are found on land and under the ocean's surface. The underwater volcanoes ooze magma which forms new oceanic crust.

Procedure

Time: 90 Minutes

Part 1. Exploring Tectonic Plates

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 a landform? Direct students to access the flashcard example as you review the vocabulary term *landform*.
- What are some examples of landforms? Direct students to access the flashcard examples as you review the vocabulary terms *hill*, *mountain*, *plain*, and *plateau*.
- Do you think they have always been there? Why do you think that?
- Do you think they have always looked the way they do today? Use evidence to support your claim.

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.

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

- Why does Earth have different landforms?
- How do you think those landforms were formed?

5. Introduce the **Dynamic Earth Interactive** by Annenberg Learner. In this interactive experience, students learn about Earth's structure, tectonic plates, and tectonic plate boundaries. Guide students to work with a partner or small group to view this interactive experience to build an understanding of this phenomenon. Students can take notes in the Launch Logs while they view the interactive experience.
6. Lead a discussion about the interactive experience.

- How would you describe the earth beneath your feet?
- Think about Earth's crust. How is the crust different from the other layers? Direct students to access the flashcard example as you introduce the vocabulary term *tectonic plate*.
- What surprised you about the tectonic plates?
- Tectonic plates cover the entire planet. What happens when they meet? Direct students to access the flashcard example as you introduce the vocabulary term *boundary*.
- There are three types of plate boundaries. Direct students to access the flashcard example as you introduce the vocabulary terms *convergent boundary*, *divergent boundary*, and *transform boundary*.
- How are the boundaries similar and how are they different? What conclusions can you draw about each boundary?
- How do tectonic plates affect the surface of Earth?

7. Now that students have learned about tectonic plates, guide them to engage in four demonstrations to explore what happens at plate boundaries. For each demonstration, have the students sketch what happens and record their observations in their Launch Logs.

8. Give each group a bag of moldable sand. Guide the students to form two tectonic plates with the sand.
   - To demonstrate convergent boundaries, push the sand plates together.
   - To demonstrate convergent boundaries, hold one sand plate in place and push the second sand plate into the first plate.
   - To demonstrate divergent boundaries, place the sand plates side-by-side and pull them apart.
   - To demonstrate transform boundaries, place the sand plates side-by-side and rub the sand plates back and forth.

9. Lead a discussion about the plate boundaries.

- What happened at the convergent boundary? Based on what you observed, how do you think this plate boundary would affect Earth?
- What happened at the divergent boundary? Based on what you observed, how do you think this plate boundary would affect Earth?
- What happened at the transform boundary? Based on what you observed, how do you think this plate boundary would affect Earth?

Part 2. Plate Boundary Maps

10. Hand out a physical map of the world and set of map overlays to each group. Direct students to access the flashcard example as you review the vocabulary term *physical map*.

11. Guide the students to place the Plate Boundaries overlay on top of the physical map of the world. Have the students make observations about the locations of the mountains and record these in their Launch Logs.

12. Lead students in a discussion about the plate boundaries.

- What conclusions can you draw about the location of mountain ranges?
- Why do you think some mountains form near plate boundaries?
- What do you remember about the Pacific Ocean when you viewed it on Google Earth?

Note: If desired, guide students to open Google Earth and view the Pacific Ocean as completed in Activity 1.

13. Lead students in a discussion about earthquakes.

- What do you know about earthquakes?
- Where do you think earthquakes are likely to occur? Why do you think this? Direct students to access the flashcard example as you introduce the vocabulary term *earthquake*.

14. Guide the students to place the Earthquake Activity overlay on top of the Plate Boundaries overlay. Have the students make observations about the location of earthquake activity and record these in their Launch Logs.

Note: Students should continue to stack the overlays on top of each other with the world physical map on the bottom.

15. Lead students in a discussion about earthquake activity.

- Based on what you observed, what conclusions can you draw about earthquake activity?
- Do you see a pattern with the plate boundaries and earthquake activity? If so, what is the pattern? Why do you think this?

16. Lead students in a discussion about volcanoes.

Activity 3

Weathering and Erosion

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
• *How Mountains Are Made* by Kathleen Weidner Zoehfeld	• PLTW Launch Logs (1 per student) • Digital devices • Pencils or colored pencils for sketching • Chart paper • Markers	• Inkling • ShowMe Interactive Whiteboard

ESSENTIAL QUESTIONS

EQ

EQ1 How has Earth changed over time?
EQ2 Why is Earth constantly changing?
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 Analyze how Earth's landforms have changed over time.
LO3 Evaluate the effect of weathering and erosion on Earth's landforms.
LO5 Collaborate effectively on a diverse and multi-disciplinary team.
LO6 Communicate effectively for specific purposes using the appropriate platform, tool, format, or digital media.
LO7 Practice ethical behavior in all settings.

KNOWLEDGE AND SKILLS

KS

KS1.2.2 Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon.
KS2.2 Explain how landforms change over time.
KS2.7 Explain how mountains are formed.
KS2.9 Identify patterns in rock formation.
KS2.10 Recognize that fossils in rock layers indicate change over time.
KS3.1 Explain ways that wind, water, ice, living things, and other agents change Earth's landforms.
KS3.2 Identify examples of weathering and erosion.
KS3.3 Explain the difference between weathering and erosion.
KS3.4 Describe how erosion affects Earth's landforms.
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.

- What do you know about volcanoes?
- Where do you think volcanoes may be likely to occur? Why do you think this? Direct students to access the flashcard example as you introduce the vocabulary term *volcano*.

17 Guide the students to place the Volcanic Activity overlay on top of the Earthquake Activity overlay. Have the students make observations about the location of volcanic activity and record these in their Launch Logs.

18 Lead students in a discussion about volcanic activity.

- What conclusions can you draw about volcanic activity? Use evidence from the maps.
- Do you see a pattern with the plate boundaries and volcanic activity? If so, what is the pattern? Why do you think this?

19 Guide students to reflect on their learning to draw conclusions based on the map observations in this activity.

- What conclusions can you draw from the location of boundary plates, mountain ranges, earthquake activity, and volcanic activity? Support your answer with evidence from the maps.
- How do natural processes, such as earthquakes and volcanoes, shape Earth?

20 When students explore careers, they can see connections between what they are learning and real-world applications. Guide students to read about Dr. Jim Kauahikaua, a research geophysicist at the U.S. Geological Survey Hawaiian Volcano Observatory.

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

Conclusion Questions Answer Key

1 What type of plate boundary causes the most noticeable change to Earth's surface? Support your answer with evidence.

Student responses should demonstrate an understanding of plate boundaries. Responses might include:
I think a convergent plate boundary causes the most noticeable change to Earth's surface. When the plates collide, an earthquake can occur or mountains or volcanoes can form.

2 Based on the evidence you have, where do you think the majority of earthquakes and volcanic eruptions are likely to occur in the future? Why do you think this?

Student responses should demonstrate an understanding of plate boundaries. Responses might include:
I think the majority of earthquakes and volcanic eruptions will occur near plate boundaries. At these boundaries, the plates collide, pull apart, or slide past each other. This activity causes earthquakes to occur and volcanoes to form. When we looked at the earthquake activity and volcanic activity maps, the majority of the activity occurred at plate boundaries.

Introduction

Earth is always changing. Sometimes the change occurs rapidly, due to a *volcanic* eruption or an *earthquake*. Other times, the change takes place over a long time.

In this activity, students learn about *weathering* and *erosion*. They observe the effects of these processes on Earth's *landforms*. Students make claims about which process(es) shaped the landforms and support their claims with evidence.

Preparation

Part 1. Weathering and Erosion

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.

boundary	A real or imaginary line that shows where one area ends and another one begins.
convergent boundary	An area where two tectonic plates push together.
divergent boundary	An area where two tectonic plates move apart.
earthquake	An area where two tectonic plates slide past each other.
erosion	The movement of weathered rock by wind, water, ice, or gravity.
landform	A natural feature of Earth's surface, such as a hill or a valley.
sediment	Solid material that is moved and deposited in a new location.
tectonic plate	A large, moving piece of solid rock.
transform boundary	An area where two tectonic plates slide past each other.
volcano	A landform where molten rock erupts from Earth's surface.
weathering	The process in which rocks are broken down by wind, water, ice, or other agents.

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. Preview the Weathering and Erosion presentation to become familiar with its content. Review the discussion questions in the Procedure.
5. Prepare a piece of chart paper titled, "Weathering and Erosion". Another option is to create the chart using the ShowMe Interactive Whiteboard app and project the chart for students to see.

Weathering	Erosion

Part 3. Read and Reflect

Read the book *How Mountains Are Made* to become familiar with its content. Review the discussion questions in the Procedure.

Possible Student Misconceptions

- **Rocks do not change**. Students tend to the view Earth as unchanging. They have a difficult time understanding that rocks can change or be worn down. Rocks break down through a process called weathering. In this process, rocks are broken down by wind, water, ice, or other agents.
- **Weathering and erosion are essentially the same thing**. **The two words can be used interchangeably**. Weathering and erosion are two different processes. Weathering is the breakdown of rock. Erosion is the movement of weathered rock by wind, water, ice, or gravity.
- **Erosion is always bad for Earth**. Erosion can have negative consequences, such as soil loss, ecosystem destruction, and sediment buildup in water sources. However, erosion can also be constructive. River deltas are created by deposition of sediments carried down river. These areas often provide fertile farmland. Without erosion, this farmland would not exist.

Procedure

Time: 70 Minutes

Part 1. Weathering and Erosion

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 students in a discussion to review Activity 1 and Activity 2.

- How does Earth change? What evidence do you have for your thinking? Direct students to access the flashcard example as you review the vocabulary terms *tectonic plate*, *boundary*, *convergent boundary*, *divergent boundary*, *transform boundary*, *earthquake*, and *volcano*.
- What are some other ways that Earth's landforms change? Why do you think the changes happen? Direct students to access the flashcard example as you review the vocabulary term *landform*.

4. Introduce weathering and erosion as processes that students will explore in this activity. Elicit students' prior knowledge of weathering and erosion and uncover misconceptions.
5. Introduce the Weathering and Erosion presentation. In this presentation, students learn about additional processes that change Earth. Guide students to work with a partner or small group to view the presentation. Students may take notes in their Launch Logs while they view the presentation.
6. Lead a discussion about the presentation. Document student responses in the chart titled, "Weathering and Erosion". Hang the completed chart in the classroom for the students to reference during the module.

- What is weathering? What causes weathering? Direct students to access the flashcard example to introduce the vocabulary term *weathering*.
- What happens to the pieces of weathered rock after they have broken off? Direct students to access the flashcard example to introduce the vocabulary terms *sediment* and *erosion*.
- How is weathering different from erosion?
- What are some examples of weathering and erosion?
- Where have you seen an example of weathering or erosion in our community? On a trip to another place?

Part 2. Making Observations

7. As you observe a photograph of the results of weathering and/or erosion, use the photograph and sample prompts to model for students how to make a claim and support it with evidence.



Claim: The landform in the photograph appears to be formed by weathering and erosion.
Evidence: I see running water in the photograph. Water can break down rock (weathering) and carry the sediment away (erosion).



Claim: This photograph shows soil erosion.
Evidence: Perhaps the soil was washed away by water in a storm. The soil that was washed away left large cracks in the ground.

8 Direct students to view the photographs of weathering and erosion in the student course with a partner or small group.

9 Guide students to:

- Make observations about the photographs.
- Record their observations in their Launch Logs.

- Make a claim about which process (weathering, erosion, or both) might have affected the landform. Support this claim with evidence.
- Optional: Have students label their claim statements and their evidence statements.

Student responses should demonstrate an understanding of weathering and erosion. Responses might include:

- The landform in Photograph 1 appears to be formed by weathering and erosion. I know this because I see water in the photograph. Over time, the water breaks down the rocks. As the sediment falls into the ocean, it gets washed away. This movement of weathered rocks is called erosion.
- The landforms in Photograph 2 appear to be formed by weathering. I know this because I see sand in the photograph. The wind picks up the sand and blows it into the rocks which causes the rock to break down. The landform also appears to be in a hot and dry location because there are few plants. The temperature could also cause the rocks to crack.
  I also notice a pile of sediment at the base of the landforms. This appears to be where the sediment fell off the landform. Erosion might have moved some of the sediment, but I do not have enough evidence to make a claim.
- Photograph 3 appears to be caused by erosion. It looks like rain fell on the field and washed the soil away.
- The landform in Photograph 4 appears to be formed by weathering and erosion. I know this because I see a river flowing through a canyon. The running water breaks down the rocks (weathering) and carries it away (erosion).
- The landform in Photograph 5 appears to be formed by weathering and erosion. I see snow in this photograph. This tells me that snow and ice break down the rock. Since I do not see a pile of sediment at the base of the landform, erosion must also be a factor.

10 Lead a discussion about the photographs and student observations. Prompts to use with each photograph:

- What process or processes did you observe in this photograph?
- What evidence do you have for your thinking?

Part 3. Read and Reflect

11 Read aloud for students the book *How Mountains Are Made*. You may choose to use a document viewer to project an image of the book.

12 Lead a discussion about the book.

- How are mountains formed?
- Why do mountains have different shapes?
- What type of plate boundaries form mountains?
- Why is Mt. Everest still growing? Support your claim with evidence.
- How is it possible for ocean fossils to be found on mountains?
- How do scientists determine the age of mountains?

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

Conclusion Questions Answer Key

1 Observe this photograph. What do you think formed this canyon? Support your claim with evidence.



Student responses should demonstrate an understanding of weathering and erosion. Responses might include:
I think the canyon was formed by weathering and erosion. I think this because I can see a river flowing through the canyon. Over many years, the river cut through the rock and broke it down. As the rock was broken down, the water carried it away.

2 Think about where you live. What is an example of weathering or erosion in your local area? What do you think caused this weathering and erosion?

Student responses will vary. Student responses should demonstrate an understanding of weathering and erosion.

3 Look at these fossil layers. What can fossils tell us about changes to Earth over time? Support your claims with evidence.



Student responses should demonstrate an understanding of fossil layers. Responses might include:
These fossil layers tell us that the habitat changed over time.
First, dinosaurs roamed the habitat. I know this because of the dinosaur fossils. These fossils tell us the habitat might have been plains or woodlands.
Then, the habitat changed. I know this because of the fish fossils. The fish fossils tell us that water covered the area.

Project

Types of Weathering

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
• Rocks: ◦ Chalk (8) ◦ Limestone (10) ◦ Tufa (10) ◦ Sandstone (10) • Dual magnifiers (8) • Dried lima beans (4 or 5 per group) • 3 oz paper cups (2 per group) • 9 oz plastic cups (4 per group) • 12 oz paper cups (2 per group) • Plaster of Paris • Water balloons (8) • Plastic spoons • Tablespoons (2) • Measuring cups (2 sets) • Sandpaper • Paper towels • Black construction paper • Plastic drainage bin (4)	• PLTW Launch Logs (1 per student) • Digital devices • Pencils or colored pencils for sketching • Markers • Water • White vinegar • Lemon juice (optional)	• Inkling • Camera

ESSENTIAL QUESTIONS

EQ

EQ1 How has Earth changed over time?

EQ2 Why is Earth constantly changing?

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.

LO3 Evaluate the effect of weathering and erosion on Earth's landforms.

LO4 Apply mathematical thinking to solve problems.

LO5 Collaborate effectively on a diverse and multi-disciplinary team.

LO6 Communicate effectively for specific purposes using the appropriate platform, tool, format, or digital media.

LO7 Practice ethical behavior in all settings.

71

KNOWLEDGE AND SKILLS — KS

KS1.2.1	Ask and identify questions to gain knowledge or solve problems.
KS1.2.2	Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon.
KS1.2.3	Analyze data to look for patterns or to test whether data are consistent with an initial prediction.
KS3.1	Explain ways that wind, water, ice, living things, and other agents change Earth's landforms.
KS3.2	Identify examples of weathering and erosion.
KS3.5	Identify examples of mechanical weathering.
KS3.6	Identify examples of chemical weathering.
KS3.7	Compare and contrast mechanical and chemical weathering.
KS4.2	Use appropriate tools strategically. [CCSS.MATH.PRACTICE. MP5]
KS4.3	Attend to precision. [CCSS.MATH.PRACTICE.MP6]
KS4.5	Organize and present collected data visually to highlight relationships and support a claim. [CSTA 1B-DA-06]
KS4.6	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.

Introduction

Students have learned that *weathering* is the process where rocks are broken down by wind, water, ice, or other agents. In this project, students explore two types of weathering—*mechanical* and *chemical*. Through investigations, students experience how acid, plants, ice, and abrasion affect rocks.

Preparation

Part 1. Mechanical and Chemical Weathering

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.

abrasion	The process in which rock is worn down by rubbing, grinding, or scraping.
chemical weathering	The process in which rock is broken down due to a chemical reaction, such as acid rain dissolving rock.
erosion	The movement of weathered rock by wind, water, ice, or gravity.
mechanical weathering	The process in which rock is broken down by physical action, such as freezing and thawing.
scientific inquiry process	A process that scientists use to explore observations and answer questions.
sediment	Solid material that is moved and deposited in a new location.
weathering	The process in which rock is broken down by wind, water, ice, or other agents.

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. Preview the Mechanical Weathering and Chemical Weathering presentations in the student course to become familiar with its content. Review the discussion questions in the Procedure.

Part 2. Break It Down

Before you begin the project, gather items needed for the investigations. The following notes for each investigation prep include the specific materials you need. Use the Family Letter in the Introduction to the Module to ask families for donations.

> **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 Part 2, 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 may need.
>
> Guided exploration allows students to build knowledge that contributes to understanding weathering. It's important that each student visit every investigation to acquire the skills necessary for completing the Problem.

Students will observe weathering and erosion through different investigations. Each investigation requires a different amount of time. Please note the time in the descriptions.

Investigation 1: Mechanical Weathering (Biological)

- Set up this investigation to allow students to explore a form of mechanical weathering. Students plant 4 or 5 dried bean seeds in a paper cup filled with plaster of Paris and make observations the next day.
- Purpose: Students observe how plants affect rock. As the seed absorbs water from the plaster of Paris, the plaster of Paris cracks. Plants are able to break down rock as they grow, which shows the strength of plants.
- Time: 2 days
- Materials: Plaster of Paris, water, 3-ounce paper cups, plastic spoons, measuring spoons, paper towels, plastic drainage bin, marker, and Launch Logs.



Investigation 2: Mechanical Weathering (Freezing and Thawing)

- Set up this investigation to allow students to explore a form of mechanical weathering. Students place a water balloon in a paper cup filled with plaster of Paris. Then, they place the cup in a freezer. The next day, students observe what happened to the plaster of Paris.
- Fill 16 water balloons. When you tie the balloons, try to remove any air.
- Purpose: Students observe how freezing and thawing affect rock. In winter, water enters the holes in rocks and freezes. The freezing water expands and cracks the rock. As the ice melts, new or larger cracks and holes are left behind.
- Time: Two days
- Materials: Plaster of Paris, water, 14-ounce paper cups, plastic spoons, water balloons, measuring cups, paper towels, plastic drainage bin, marker, and Launch Logs.



Investigation 3: Chemical Weathering

- Set up this investigation to allow students to explore chemical weathering. Students place each rock in a cup with white vinegar. Students observe what happens to each rock and record their observations in their Launch Logs.
- Prepare a set of rocks for each group. Each set should include chalk, limestone, tufa, and sandstone. Make sure that each group gets their own set of rocks to observe chemical weathering.
- Purpose: Students observe how vinegar, an acid, affects rock. As the students pour vinegar on the rocks, they observe the rocks bubbling or fizzing. They may even notice a sound. Students should also observe sediment at the bottom of the cup.
- Time: One day or two days
- Materials: Chalk, limestone, tufa, sandstone, dual magnifiers, 12-ounce plastic cups, lemon juice, vinegar, paper towels, and Launch Logs.



Investigation 4: Mechanical Weathering (Abrasion)

- Set up this investigation to allow students to explore a form of mechanical weathering. Over black construction paper, students rub four rocks with a piece of sandpaper. Students observe what happens to each rock and record their observations in their Launch Logs.
- Prepare a set of rocks for the investigation. Each set should include chalk, sandstone, limestone, and tufa.
- Purpose: Students observe how rubbing or scraping affects rock. As students rub the rocks with sandpaper, they observe how some rocks break apart. They observe sediment or dust on the black construction paper or on the sandpaper.
- Time: 1 day
- Materials: Chalk, sandstone, limestone, tufa, sandpaper, black construction paper, and Launch Logs.



Duplicate each investigation as needed to accommodate your class size.

Part 3. Let's Take a Walk

Take a walk around the school to determine the best route for students to identify examples of weathering. Consider a route where students can observe cracks in the sidewalk, potholes, or weathered rocks.

Possible Student Misconception

Animals do not cause weathering. The breakdown of rocks by plants and animals is called biological, or organic, weathering. This is a form of mechanical weathering due to a living organism. Many animals like to dig. This digging can break apart rock. Whether an animal digs tunnels underground or digs above ground, the digging can weather the rocks in the soil.

Procedure

Time: 120 Minutes

Part 1. Mechanical and Chemical Weathering

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 is weathering? Direct students to access the flashcard example as you review the vocabulary term *weathering*.
- What is erosion? Direct students to access the flashcard example as you review the vocabulary term *erosion*.
- In what ways are weathering and erosion different? Share examples that show how these processes are different.

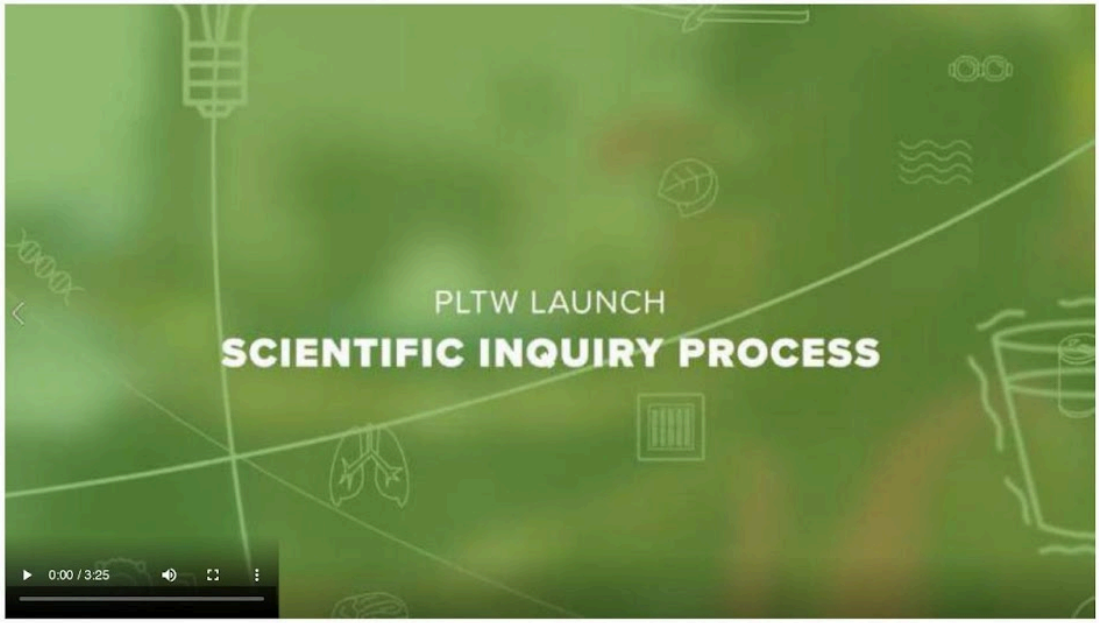
> Possible student response:
> Weathering is the process in which rocks are **broken down** by wind, water, ice, or other agents. Erosion is the **movement** of weathered rock by wind, water, ice, or gravity. These processes may work together, but they are different.

4. Introduce the Mechanical Weathering and Chemical Weathering presentations. In these presentations, students learn about two types of weathering—mechanical weathering and chemical weathering. Guide students to work with a partner or small group to view the presentations. Have students take notes in their Launch Logs about the two types of weathering.
5. Lead a discussion about the presentations.

- What is mechanical weathering? Direct students to access the flashcard example as you introduce the vocabulary term *mechanical weathering*.
- How does mechanical weathering affect rock?
- What are some examples of mechanical weathering?
- Where have you seen mechanical weathering?
- What is chemical weathering? Direct students to access the flashcard example as you introduce the vocabulary term *chemical weathering*.
- How does chemical weathering affect rock?
- What are some examples of chemical weathering?
- Where have you seen chemical weathering?

Part 2. Break It Down

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



Scientific Inquiry Process video

8 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?

9 Introduce the following investigations to the students in detail. Be sure to present new tools or equipment, such as how to use the dual magnifiers. Remind students that, as they investigate mechanical and chemical weathering, they will use the same process as scientists.

- **Investigation 1: Mechanical Weathering (Biological)**

  Guide students to:

  Prepare
  - Prepare their Launch Logs to record the question, predictions, and observations.
  - Use a marker to write their names or initials on two 3-ounce paper cups.
  - Label one paper cup "beans" and the second paper cup "no beans".
  - Place the paper cups inside the plastic drainage bin.
  - Place 2 tablespoons of plaster of Paris in each cup.
  - Add 1 tablespoon of water to each cup.
  - Carefully mix the plaster of Paris and water.

  Plant
  - Place 4 or 5 dried lima beans in the cup labeled "beans".
  - With the spoon, push the beans under the surface of the plaster of Paris.

  Predict
  - Make a prediction about what will happen in both cups.
  - Record the predictions in their Launch Logs.

  Observe
  - Place the cup in the teacher-designated area to harden.
  - Observe what happens over the next few days.
  - Record the results in their Launch Logs.

  Students should not notice any change in the cup without beans. The plaster of Paris should look exactly the same on Day 1 and Day 2. Students should notice cracks in the plaster of Paris in the cup with beans on Day 2.

- **Investigation 2: Mechanical Weathering (Freezing and Thawing)**

  Guide students to:

  Prepare
  - Prepare their Launch Logs to record the question, predictions, and observations.
  - Use a marker to write their names or initials on two 14-ounce paper cups.
  - Label one paper cup "freezer" and the second paper cup "room temperature".

- Place the paper cups inside the plastic drainage bin.
- Add 1 cup plaster of Paris to each paper cup.
- Add ½ cup water to each paper cup.

> **Note**: The measurements of plaster of Paris and water may vary due to the size of the water balloons. Adjust the measurements accordingly, but keep the ratio 2:1 of plaster of Paris and water.

- Carefully mix the plaster of Paris and water.

Place

- Place a water balloon in each paper cup.
- Push the water balloons under the surface of the plaster of Paris.

Predict

- Make a prediction about what will happen in the cup labeled "freezer" after it is frozen.
- Make a prediction about what will happen in the cup labeled "room temperature" as it sits in the classroom overnight.
- Record the predictions in their Launch Logs.

Observe

- Place the cups in the teacher-designated area to harden.
- When the plaster of Paris is hard, place the cup labeled "freezer" in the freezer overnight.
- The next day, remove the cup from the freezer.
- Observe what happened to the plaster of Paris in both cups and record these observations in their Launch Logs.

> Students should not notice any change in the cup labeled "room temperature". The plaster of Paris should look exactly the same on Day 1 and Day 2. Students should notice cracks in the plaster of Paris in the cup labeled "freezer" on Day 2. They should see how the ice expanded and pushed through the plaster of Paris.

- **Investigation 3: Chemical Weathering**

Guide students to:

Prepare

- Prepare their Launch Logs to record the question, predictions, and observations.
- Place sandstone, tufa, limestone, and chalk in plastic cups with one rock per cup.

Predict

- Make a prediction about what will happen when they pour white vinegar on each rock.
- Record this prediction in their Launch Logs.

Investigate and Observe

- Pour white vinegar on one rock at a time.
- Make observations with the naked eye and the dual magnifier. Record the results in their Launch Log.
- Remove each rock from the vinegar and rinse with water. Leave the rock out to dry.
- Make observations about what remains in the cup. Record these observations in their Launch Logs.

> **Optional**: Repeat this investigation the next day with lemon juice.

> Students should observe bubbling and fizzing when the tufa, limestone, and chalk come into contact with vinegar. They should notice different amounts of bubbling and fizzing, too. The tufa and chalk react more than the limestone. Students should not notice a reaction with the sandstone.

- **Investigation 4: Mechanical Weathering (Abrasion)**

Guide students to:

Prepare

- Prepare their Launch Logs to record the question, predictions, and observations.
- Hand out a rock to each group member.

Predict

- Feel each rock with their fingers.
- Make a prediction about what will happen when they rub the chalk, sandstone, limestone, and tufa with sandpaper.
- Record this prediction in their Launch Logs.

Investigate and Observe

- Over a piece of black construction paper, rub one rock with sandpaper.
- Observe what happens and record the results in their Launch Logs.
- Pass the rock to a group member.
- Repeat this process until all rocks have been tested.

Students should notice dust and small pieces of sediment on the sandpaper. If students feel the rocks after sanding, they may get dust on their fingers, too. The amount of sediment depends on the rock, the grit of the sandpaper, and the force applied while sanding. If students did not observe any sediment from a specific rock, highlight that in the class discussion.

10 Guide students to rotate through the four investigations to explore more about the types of weathering.

11 As students rotate through the investigations, ask questions and observe student interactions to formatively assess their understanding of weathering. Uncover and address any misconceptions as students explore the types of weathering.

12 Have the students bring their Launch Logs and join you on the carpet. Lead students in a discussion of what they discovered in the Chemical Weathering and the Mechanical Weathering (Abrasion) investigations.

- Investigation 3: Chemical Weathering
  - Describe what happened when you poured vinegar on each rock.
  - Did every rock react the same way? How were they similar? How were they different? Why do you think there were different reactions?

    > **Note**: Rocks that contain calcium carbonate release carbon dioxide when exposed to vinegar. This carbon dioxide looks like bubbles in soda. If the rocks do not contain calcium carbonate, they will not fizz.

  - What did you observe at the bottom of each cup? Direct students to access the flashcard example as you review the vocabulary term *sediment*. Did every cup have the same amount of sediment? Why do you think this?
  - Vinegar is an acid. How do you think acid rain affects different landforms? Support your claim with evidence.
  - Where do you think this type of chemical weathering occurs? Why do you think that?
- Investigation 4: Mechanical Weathering (Abrasion)
  - Describe what happened when you rubbed each rock with sandpaper. How were the results similar? How were the results different? Direct students to access the flashcard example as you introduce the term *abrasion*.
  - Why do you think the results were different for each rock? Support your claim with evidence.
  - How do you think abrasion occurs naturally? Why do you think this?
  - Where do you think this type of mechanical weathering occurs? Why do you think that?

13 The next day, guide students to observe the cups filled with plaster of Paris from the Mechanical Weathering (Freezing and Thawing) investigation and the Mechanical Weathering (Biological) investigation. Have them document their observations in their Launch Logs.

14 Have the students bring their Launch Logs and join you on the carpet. Lead students in a discussion of what they discovered in the Mechanical Weathering (Freezing and Thawing) and the Mechanical Weathering (Biological) investigations.

- Investigation 1: Mechanical Weathering (Biological)
  - Describe the cup without any beans.
  - Describe the cup with beans.
  - How are these cups different?
  - What do you think caused the differences? Support your claim with evidence.
  - Where do you think this type of mechanical weathering occurs? Why do you think that?
- Investigation 2: Mechanical Weathering (Freezing and Thawing)
  - Describe how your cup looks after a night in the freezer.
  - Why do you think the plaster expanded and cracked? Support your claim with evidence.
  - What do you think will happen when the water thaws? Why do you think that? What would happen if the water freezes again after it thaws out?
  - Where do you think this type of mechanical weathering occurs? Why do you think that?

Part 3. Let's Take a Walk

15 Introduce the outdoor walk to students. On this walk, students work in groups of 3 or 4 to observe local examples of weathering and erosion. Guide students to use digital devices and Launch Logs to:

- Take photographs
- Sketch pictures
- Write down observations

16 Throughout the walk, ask students questions about their discoveries.

- Describe the characteristics of the land around the school.
- What do you notice about the land around you?
- Have you found any examples of weathering and erosion? What did you find?

Note: If students draw different conclusions about what they observe, guide them to provide evidence for their thinking. Encourage students to work together to form a conclusion.

17 Lead a discussion about the outdoor walk.

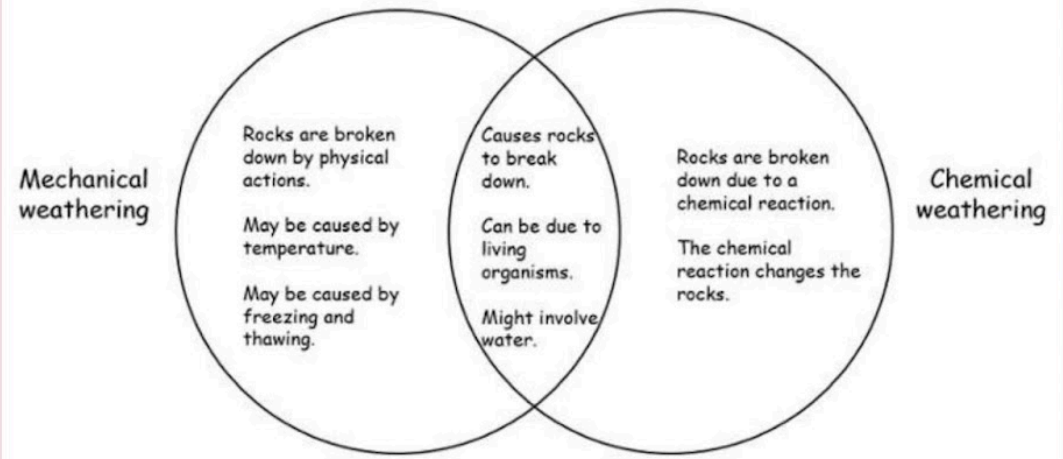
- What examples of weathering and erosion did you find around the school?
- What evidence did you use to identify the example as weathering or erosion?
- Share an example of weathering that you observed. What evidence do you have to support your conclusion that the examples shows weathering?
- How does this example of weathering connect to the investigations? Does the example of weathering represent mechanical or chemical weathering? Support your claims with evidence.
- Share an example of erosion you observed. What evidence do you have to support your conclusion that the examples show erosion?

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

Conclusion Questions Answer Key

1 In your Launch Log, draw a Venn diagram to compare and contrast mechanical and chemical weathering.

Student responses should demonstrate an understanding of mechanical and chemical weathering. Responses might include:



2 Think about an example of weathering you have seen. Make a claim about how weathering has affected this landform.

Student responses will vary.

Problem

Earth Rocks!

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) • Digital devices • Pencils or colored pencils for sketching	• Inkling • Digital product apps, such as: ◦ Video function on a device ◦ iMovie ◦ Kapwing

RESOURCES

R

- Research Resources
- Storyboard Resource Sheet
- Decision Matrix
- Summative Assessment

ESSENTIAL QUESTIONS

EQ

EQ1 How has Earth changed over time?
EQ2 Why is Earth constantly changing?
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 Analyze how Earth's landforms have changed over time.
LO3 Evaluate the effect of weathering and erosion on Earth's landforms.
LO4 Apply mathematical thinking to solve problems.
LO5 Collaborate effectively on a diverse and multi-disciplinary team.
LO6 Communicate effectively for specific purposes using the appropriate platform, tool, format, or digital media.
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 and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon.
KS2.1	Identify basic landforms of Earth.
KS2.2	Explain how landforms change over time.
KS3.1	Explain ways that wind, water, ice, living things, and other agents change Earth's landforms.
KS3.2	Identify examples of weathering and erosion.
KS3.4	Describe how erosion affects Earth's landforms.
KS4.1	Make sense of problems and persevere in solving them. [CCSS.MATH.PRACTICE.MP1]
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.

Introduction

In this problem, students follow the *design process* to research, create, and reflect on a *documentary* that explains how one of Earth's landforms has been shaped over time.

Preparation

Professional Development PD

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 vocabulary terms used in this problem. Plan how you will help students use these terms as part of their vocabulary.

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.
documentary	A presentation that tells facts about actual people and events.

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. Anticipate landforms that students may select in the problem. Visit your local library to gather books on landforms. Some landforms shaped by weathering and/or erosion include:
   - Grand Canyon
   - Monument Valley
   - Big Bend National Park (Santa Elena Canyon)
   - Arches National Park
   - Uluru, formerly known as Ayers Rock
   - Pictured Rocks National Lakeshore
   - Vermillion Cliffs National Monument
   - Antelope Canyon
   - Badlands National Park
   - Bryce Canyon
   - Zion National Park
5. Review the **Research Resources** and select books, websites, and other materials students can use to do research during the Explore portion of the design process.
6. To make a connection to the Introduction Story: *The Amazing Earth*, think of ways for students to present their documentaries outside of the classroom. Some options include presenting at the local library, museum, or school board meeting. If students are unable to present outside the classroom, invite guests to observe student documentaries. Guests can include parents, school board members, or local community leaders.
7. Become familiar with the **Storyboard Resource Sheet**. Students use this storyboard to help them plan out each part of their digital product. It is a graphic representation of how the digital product unfolds.
8. As students work through the design process to develop a solution, use the Earth: Past, Present, and Future 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.
9. 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.

Procedure

Time: 210 Minutes

1. Direct students to access the problem in the student course and have them read the Introduction. As you guide them to review the problem statement, allow students to share their thoughts and excitement about designing a documentary that explains how one of Earth's landforms has been shaped over

time.

2. Introduce the design process that students will use to guide their work on solving the problem.
   - 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.

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



Design Process video

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

   - Why do engineers use the design process? Direct students to access the flashcard example as you review the vocabulary term *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.

5. For the problem, the Launch Log has a guided section titled, "Solving the Problem." Guide students to locate and preview this section in their Launch Log. 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.

6. Guide students to follow the design process to research, create, and reflect on a documentary that explains how one of Earth's landforms has been shaped over time. Use the flashcard example to introduce the vocabulary term *documentary*. Provide support for students to understand that a documentary is a presentation that provides information and facts about a subject.

   Note: Consider the audience that will view the students' documentaries. Share this information with students so they can create a documentary appropriate for that audience.

7. 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 documentary that explains how one of Earth's landforms has been shaped over time?"
   - Introduce the idea of defining *criteria* and *constraints* to provide guidelines for their work. Direct students to access the flashcard examples as you introduce the vocabulary terms *criteria* and *constraint*.

Criteria	Constraints
The documentary: • Focuses on one landform. • Explains how weathering and/or erosion shaped the landform. • Includes how the landform was created due to plate tectonics, if applicable. • Includes pictures and/or models of the landform. • Presents the information in an exciting way. • Must be presented in the form of a digital product.	• Time • Digital product apps • 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?
  - 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.

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

- Introduce the Explore step of the design process as a time to explore possible solutions to the design problem. Remind students to use the Explore section of the Launch Log to record their ideas throughout this step.
- Guide students to work in groups to select a landform for their documentary.
  - Allow time for students to brainstorm a list of landforms that interest the group members.
  - Set the stage for students to research information needed to make an informed decision about the landform to be featured in their documentary. Students should apply what they have learned in the activities and the project to guide their thinking. Remind them to consider what they know about Earth's landforms, tectonic plates, weathering, and erosion.
  - Direct students to make a group decision about the landform for their documentary.

> **Note**: This open-ended problem allows students the freedom to select a landform of their choice. Students can select a local landform, a landform in their state, a landform in their country, or a landform in the world. However, other students may need assistance to select a landform. See the Preparation section to find a list of landforms shaped by weathering and erosion.

- Now that groups have selected a landform, guide them to work individually or in pairs to brainstorm ideas for how to solve the problem of designing a documentary.
  - Students may use the skills and knowledge they gained from the activities and project in this module, as well as any information they gathered from their research.
  - Direct students to review the problem statement, the criteria, and the constraints to serve as a guide for the development of their plan.
  - Students record their ideas for planning the documentary in the Explore section of the Launch Log. It may include a sketch of visuals and a description of the documentary.
  - Students prepare to share their ideas with their group in the Model step of the design process.
- Have students complete the self-reflection at the end of the Explore section. Assess student understanding and record comments as needed.

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

- Review the Model step of the design process. In this step, students make a decision about the best design for their documentary, and then they develop the documentary using the criteria and constraints as a guide.
- Introduce a decision matrix as a way to decide on the best documentary. Using the **Decision Matrix**, students rate each group member's documentary based on a 0–1 scale for each category. If the documentary does not meet the criterion in a category, it receives a 0 in that category. If the documentary does meet the criterion, it receives a 1. The documentary 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.

- Provide each group a copy of the **Storyboard Resource Sheet**.

- If needed, provide an explanation of what a storyboard is and how it is used. Students use this storyboard to help them plan out each part of their documentary. It is a graphic representation of how the documentary unfolds.
- Guide students to use the chosen idea to develop a plan for their documentary on the storyboard.
- As students develop their storyboard, provide guidance as needed to help students build their ideas using the criteria and constraints for the problem.
- Assess student progress in applying what they have learned about Earth's landforms, tectonic plates, weathering, and erosion to their documentary.
- Upon completion of the storyboards, direct students to develop their documentaries. Students may elect to build models, create maps, or include photographs or sketches to provide information and facts about the landform.
- To facilitate creation of the documentary, spend time with groups, providing support, allowing students to share their thinking as they work. This allows you to assess:
  - Student demonstration of conceptual understanding
  - Problem-solving skills
  - Collaborative skills
- Have students complete the self-reflection at the end of the Model section. Assess student understanding and record comments as needed.

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

- Review the Evaluate step with students. Remind them that this valuable step allows them to assess how well they have solved or not solved the problem.
- Guide students to view their documentary and reflect on its strengths and weaknesses.

  - Is the content accurate?
  - Does the documentary address all the criteria?
  - Is the documentary visually exciting?
  - What can we do to improve the documentary?

- Have students partner with another group to complete a cross-team review. Guide each group to view the other group's documentary and provide constructive feedback on how to improve the documentary.
- After students identify the strengths and weaknesses of their documentary and complete a cross-team review, provide time for them to iterate on their design to ensure it successfully solves the design challenge.
- Have students complete the self-reflection at the end of the Evaluate section. Assess student understanding and record comments as needed.

11 The fifth step in the design process is **Explain**

- Provide time for students to share their documentaries.

FAMILY CONNECTION (OPTIONAL)

To make a connection to the Introduction Story: *The Amazing Earth*, think of ways for students to present their documentaries outside of the classroom. Options include presenting at the local library, museum, or school board meeting. If students are unable to present outside the classroom, invite guests to observe student documentaries. Guests can include parents, school board members, or local community leaders.

- After all presentations, lead a discussion about the features, strengths, and weaknesses of the different documentaries.

  - What key takeaway do you have after viewing all the documentaries?
  - How would you compare and contrast your landform with those shared by other groups?
  - If you could improve anything about your documentary, what would you improve? Why would you improve that aspect?
  - If you could create another documentary, what landform would you research? Why would you research that?
  - What was the most challenging part of the design process? Why do you think that?
  - Describe a challenge or task that you had to solve step by step. How did it help you to work on the challenge or task one step at a time?

- Guide students to complete the Explain section of their Launch Logs. Have students provide suggestions for improvement for their documentaries 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.

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

13 Direct students to complete the Earth: Past, Present, and Future 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 List two changes you would make to improve your documentary. Why do you think these changes would improve it?

Student responses will vary.

2 Based on what you learned throughout the module, how do you think the landform you presented will look in the future? What evidence do you have to support your answer?

Student responses will vary.

Introduction to the Module

Energy: Collisions

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: Energy: Collisions Teacher Guide.

PREFACE

Time: 10 instructional hours

This module begins with three fictional characters at an amusement park observing bumper cars. Through the example of the bumper cars, students are introduced to energy transfer and conversion in collisions. The students apply new skills and knowledge to solve a design problem where they are asked to design and build a restraint system to protect a passenger in a vehicle collision. The passenger is represented by an egg. The vehicle rolls down an inclined plane and collides with a solid object such as a wall.

Students explore how mechanisms change energy by transferring direction, speed, type of movement, and force. Students discover a variety of ways that potential energy can be stored and released as kinetic energy. Citing evidence, students explain the relationship between the speed of an object and the energy of that object. They also predict the transfer of energy as a result of a collision between two objects. As students solve the problem for this module, they will apply their knowledge and skills related to energy transfer in collisions to develop a vehicle restraint system.

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. Predict the effects of a collision.

UNDERSTANDINGS

U

Students will understand that ...

1. Engineers have a step by step approach of looking at and solving 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 to develop 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. Energy is the ability to do work.
9. Engineers design mechanisms to change energy by transferring direction, speed, type of movement, and force.
10. Potential energy can be stored in many ways and is released as kinetic energy.
11. The faster a given object is moving, the more energy it possesses.
12. Contact forces transfer energy during a collision, resulting in a change in the object's motion.

KNOWLEDGE

K

It is expected that students will ...

- Explain what happens at each step of the design process.
- State questions engineers may ask when gathering information about a situation people want to change.
- Identify the differences between invention and innovation.
- List ways in which energy can be transferred.

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.
- Classify energy in a system as potential or kinetic energy.
- Explain, citing evidence, the relationship between the speed of an object and the energy of that object.
- Predict the transfer of energy as a result of a collision between two objects.
- Solve a simple design problem involving the transfer of energy and collisions between two objects.

ESSENTIAL QUESTIONS

EQ

1. How are potential and kinetic energy related?
2. What happens to energy during a collision?

RESOURCES

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

Preparation

> **Note:** In preparation for teaching this module, it is strongly recommended that the teacher read the Energy: Collisions 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 app or browser cannot be used to view the steps, a video is available in the student course, titled VEX IQ Video Resources. Direct students to use the video only if Fusion 360 is not accessible.

> **Note:** There are two versions of the PLTW VEX IQ Construction Kit and PLTW VEX IQ Robot Design Kit. Either kit version may be used to construct the assemblies required for this module.

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 Energy: Collisions 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 **Energy: Collisions Module-specific PD Resources** to review:
  - Energy: Collisions APB Overview
  - Building Your Understanding: Mechanical Energy
  - Building Your Understanding: Conservation of Energy Part 1
  - Building Your Understanding: Conservation of Energy Part 2
  - Building Your Understanding: Conservation of Energy Part 3
  - Energy: Collisions Misconceptions
  - 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 **Fourth Grade Curriculum Revisions**.



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Activity 1

Energy

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.

Not Included in Equipment Kit	Device Applications
• Launch Logs • Digital devices	• Inkling • Camera • Optional: ◦ SloPro (iPad®) ◦ Kapwing (Android or Chrome OS)

RESOURCES

- Launch Log Grades 3-5
- Introduction to Energy: Collisions
- VEX IQ Equipment List - Vehicle
- How to Access VEX IQ Assembly Instructions

LEARNING GOALS

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

- State questions that engineers may ask when gathering information about a situation people want to change.
- List ways in which energy can be transferred.

ESSENTIAL QUESTIONS

EQ

1. How are potential and kinetic energy related?
2. What happens to energy during a collision?

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: Energy

120 minutes

- In preparation for the vehicle demonstration, the teacher will assemble the vehicle following the instructions found in the Fusion 360 **Vehicle** link. For more information on Fusion 360, review the **Introduction to the Module**.
- The teacher begins the module with a demonstration involving an egg sitting on the basic vehicle design and rolling down the metal ramp to hit a wall. The egg should break or at least crack. It is fine if the egg falls out of the vehicle part way down and cracks on the ramp. If the egg does not break, you may need to increase the angle of the ramp and repeat the demonstration. During pilot testing organic eggs were found to have thicker shells and were more difficult to break at the standard angle of the ramp.
- During the demonstration the teacher may wish to record the collision with the camera feature or a slow motion app such as SloPro on an iPad® or Android device. If using a Chromebook, teachers may convert the video using Kapwing.
- After the demonstration the teacher leads a discussion about what the students observed and encourages the students to propose questions they have about the demonstration.
- The teacher explains that at the conclusion of the module, students will be asked to build the same vehicle, only they must transfer their egg successfully down the ramp and hit the wall without breaking the egg.
- The teacher distributes the Launch Log. In the "Ask" section the students answer the two prompts below:

  a. What is the need or want that we are trying to fulfill?
  b. What will make the design solution successful?
  c. Note: the question about constraints will be answered in the Problem.

- The teacher leads a class discussion around the question of where to start when facing a challenge. The teacher describes the design process and explains that the Launch Log will be used to document all of their work related to the vehicle restraint design problem. The Launch Log will also be used to document student work throughout the Energy: Collisions module.
- The teacher introduces students to the curriculum course and assists students with the login process. For the remainder of the module, the students will access assignments in the curriculum course.
- The teacher assists students in accessing the Energy: Collisions module.
- The students read the Energy: Collisions Introduction about the three fictional characters and the bumper car ride at the amusement park. The Introduction may be accessed in the curriculum course or printed for students.
- The students discuss the problem and how it relates both to the fictional story and to the vehicle restraint system they are asked to design in this module.
- The teacher guides the students to Activity 1: Energy and reads the introduction with the students.
- In this activity the students read an article on seat belt safety and discuss the reading with a classmate.
- The teacher leads a class discussion on what the students learned and if they have any ideas on how to protect their egg passenger in the final design problem.
- The students complete Activity 1: Energy and answer Conclusion Questions. The students may complete all work in the Launch Log.

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 Why is it important to know about energy and forces when designing a seat belt?

Student responses should demonstrate an understanding of how seat belts protect passengers. Example response:

The designer needs to think about how the seat belt can protect the passengers from the forces applied to their body during a collision, and safely stop them from moving forward.

2 When should you wear a seat belt? Why?

Student responses should demonstrate an understanding of the importance of seat belts. Example response:

You should wear a seat belt any time you are in a car or ride that has them. They keep us safe in collisions by absorbing energy and keeping us in the seat.

Activity 2

Potential and Kinetic Energy

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.

Not Included in Equipment Kit	Device Applications
• Launch Logs • Digital devices	• Inkling • ShowMe Interactive Whiteboard • PhET® simulation Energy Skate Park: Basics

KNOWLEDGE AND SKILLS

KS

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

- List ways in which energy can be transferred.
- Classify energy in a system as potential or kinetic energy.

ESSENTIAL QUESTIONS

EQ

1. How are potential and kinetic energy related?
2. What happens to energy during a collision?

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: Potential and Kinetic Energy

80 minutes

- Assist the students in navigating to Activity 2: Potential and Kinetic Energy in the curriculum course.
- Demonstrate potential and kinetic energy with the VEX IQ vehicle and a ramp. Use the Potential and Kinetic Energy presentation which is in Resources in the curriculum course to accompany the demonstration.
  - The teacher identifies the top of that ramp as the position where the vehicle has the most potential energy. Before the vehicle is released it has no kinetic energy.
  - The teacher identifies the bottom of the ramp as the position where the vehicle has the most kinetic energy, which means it is moving the fastest. At the bottom of the ramp the vehicle has no potential energy.
  - The teacher identifies the middle part of the ramp as a position where the vehicle has both potential and kinetic energy.
- Direct students to the **PhET® simulation Energy Skate Park: Basics** and give an introduction of the simulation to the class. Students can find the link on the Resources page. The teacher should test the link and simulation prior to presenting to students.
- Guide students to use the Intro simulation and to display the Bar Graph which shows the skater's kinetic, potential, and total energy. There is no thermal energy because there is no friction in the simulation.
- Students explore the simulation, identifying the kinetic energy and potential energy of the skater.
- When students explore careers, they can see connections between what they are learning and real-world applications. Guide students to read about Sandra Begay, a research and development systems engineer, who has a passion to help others.
- The students answer conclusion questions for Activity 2: Potential and Kinetic Energy in their Launch Logs.
- Alternatively, teachers may direct students to take screenshots of the simulation and create a ShowMe Interactive Whiteboard presentation that answers the Conclusion Questions with an image and an explanation.

Conclusion Questions Answer Key

1 Explain when the skater in the simulation has the greatest amount of potential energy.

Student responses should demonstrate an understanding of potential energy. Example response:

The skater in the simulation has the greatest amount of potential energy when they are at the top of the ramp.

2 Explain when the skater in the simulation has the greatest amount of kinetic energy.

Student responses should demonstrate an understanding of kinetic energy. Example response:

The skater in the simulation has the greatest amount of kinetic energy when they are at the bottom of the ramp.

3 Explain when the skater in the simulation has approximately equal amounts of potential energy and kinetic energy.

Student responses should demonstrate an understanding of the difference between potential and kinetic energy. Example response:

The skater in the simulation has approximately equal amounts of potential energy and kinetic energy when they are halfway down the ramp.

Activity 3

Speed and Energy

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.

Included in Equipment Kit	Not Included in Equipment Kit	Device Applications
• Sheets of poster board (1 per group)	• Launch Logs • Digital devices • VEX® IQ Construction or Robot Design Kit (1 per group) • Rulers (1 per group) • Masking tape	• Inkling • Internet browser for Fusion 360 links • Camera • Slow motion video analysis, such as: ◦ SloPro (iPad®) ◦ Kapwing (Android or Chrome OS)

RESOURCES

- PLTW VEX IQ Construction Kit Contents - V1
- PLTW VEX IQ Construction Kit Contents - V2
- PLTW VEX IQ Robot Design Kit Contents - V1
- PLTW VEX IQ Robot Design Kit Contents - V2
- VEX IQ Equipment List - Pendulum
- VEX IQ Equipment List - Vehicle
- How to Access VEX IQ Assembly Instructions

KNOWLEDGE AND SKILLS

KS

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

- Classify energy in a system as potential or kinetic energy.
- Explain, citing evidence, the relationship between the speed of an object and the energy of that object.

ESSENTIAL QUESTIONS

EQ

1. How are potential and kinetic energy related?
2. What happens to energy during a collision?

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: Speed and Energy

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 use.

- In this activity students explore the relationship between speed and energy of an object by assembling a simple model of a pendulum and vehicle and documenting the changes to the system that can increase or decrease the speed of the objects. Changes to the system will include varying the amount of potential energy by altering the mass or initial height of the objects.
- If this is the first time students will work with the VEX IQ equipment, the teacher may wish to allow students time to explore how the pieces fit together and how the kit is organized. The PLTW VEX IQ kit contents can be found in the resources. This module may be completed using either the VEX IQ Construction or Robot Design Kit.
- The teacher assists the students in navigating to Activity 3: Speed and Energy in the curriculum course.
- In Part 1 the students build the pendulum and document the effect of raising the pendulum to different heights prior to release. There are enough parts in either kit to build two pendulums.

  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 each build.

- The teacher may have the students complete the assignment on paper or record a video of the pendulum movement along with student responses to share with the class.
- Before proceeding to Part 2 the students should disassemble the pendulums and return the parts to the proper kit.
- In Part 2 the students build the vehicle following the directions presented in the Fusion 360 link. Each PLTW VEX IQ kit has enough parts for two vehicles.
- The poster board is taped to a wall or chair and the ground to create a ramp for the vehicle assembly. Students will roll the vehicles down the ramp and make observations related to speed and energy.
- The students record videos of the vehicles as they travel down the ramp and describe the relationship between speed and energy. Specifically, students consider the relationship between speed, kinetic energy, and potential energy. An example of an explanation might be that a vehicle starting from rest at a greater height has a higher potential energy. That energy is converted into kinetic energy resulting in a higher vehicle speed. The kinetic energy is absorbed as the vehicle travels across the floor as it comes to a rest.
- The students complete Activity 3 and Conclusion Questions.
- The vehicles will be used throughout the remainder of the module and should remain assembled.

Conclusion Questions Answer Key

1 How does the amount of potential energy, or energy stored in the pendulum just before it is released, affect the motion of the pendulum?

Student responses should demonstrate an understanding of potential energy. Example response:

The more potential energy the pendulum has, the higher it swings back and forth. For example, when I raised the pendulum to its highest point, it swung back and forth the highest. When I raised the pendulum at a lower point, it swung back and forth lower.

2 How does the amount of potential energy, or energy stored in the vehicle just before it rolls down the ramp, affect the distance traveled by the vehicle?

Student responses should demonstrate an understanding of potential energy. Example response:

The more potential energy the vehicle has, the farther it travels. For example, when I raised the vehicle to the 14-inch height, it traveled the farthest distance. When I raised the vehicle to the 6-inch height, it traveled the shortest distance.

3 What is the relationship between the speed and energy of an object?

Student responses should demonstrate an understanding of speed and energy. Example response:

Speed and energy are directly related. When an object, like the vehicle, has more potential energy, the kinetic energy and speed are more too When an object has less potential energy, the kinetic energy and speed are less too.



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Project

Energy Transfer in Collisions

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.

Included in Equipment Kit	Not Included in Equipment Kit	Device Applications
• Sheets of poster board (2 per group) • Pipe Insulation, ½ inch x 6 feet (2 per group, optional)	• Launch Logs • Digital devices • VEX® IQ Construction or Robot Design Kit (1 per group) • Masking tape	• Inkling • Camera • Slow motion video analysis, such as: ◦ SloPro (iPad®) ◦ Kapwing (Android or Chrome OS) • Internet browser for Fusion 360 links

RESOURCES

Energy Transfer in Collisions Student Charts

VEX IQ Equipment List - Vehicle Weighted

KNOWLEDGE AND SKILLS

KS

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

- Explain, citing evidence, the relationship between the speed of an object and the energy of that object.
- Predict the transfer of energy as a result of a collision between two objects.

ESSENTIAL QUESTIONS

EQ

1. How are potential and kinetic energy related?
2. What happens to energy during a collision?

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: Energy Transfer in Collisions

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 this project students will describe elastic and inelastic collisions in systems they construct using VEX IQ equipment. Students will also describe how energy is conserved and transferred in a collision, including changes in motion and the production of heat and sound.
- The teacher will guide the students in discussing the sound created by a vehicle accident and relating that sound production to the sound created by clapping hands.
- The teacher assists the students in navigating to Project: Energy Transfer in Collisions in the curriculum course.
- The students use the vehicles they assembled in the previous activity. Each group will require 2 vehicles, 2 pieces of poster board, masking tape, and the additional VEX IQ parts as described for the project. If available, pipe insulation may be added to the edge of the poster board for increased strength.

  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 vehicle weighted.

- The teacher reads through the introduction with the students and reviews the new key terms. The informational text in the introduction may be used to demonstrate close reading.
- To complete the project, the students will need to record their observations on a chart in their Launch Logs. They may copy the chart provided in the curriculum course, or the teacher may wish to print the chart and have students tape or glue the charts into their Launch Logs.
- The students complete Project: Energy Transfer in Collisions and answer the Conclusion Questions.
- Students may capture collisions using an app that allows playback in slow motion. A possible app to record the collisions is a slow motion video analysis such as SloPro. If using Chromebooks, students may capture the collisions using the camera on the device and convert the video using Kapwing.
- Remove only the parts added in this project. The original vehicle used in Activity 3: Speed and Energy will be used in the Problem.

Conclusion Questions Answer Key

1 Why do bumper cars have a rubber bumper around each of the cars as shown here? Explain.



Student responses should demonstrate an understanding of collisions. Example response:

The rubber bumpers absorb some of the energy of the collision and allow the bumper cars to bounce off each other instead of damaging the cars.

2 Look at the figure below with the toy cars on a ramp. Which car has more potential energy? Why?



Student responses should demonstrate an understanding of potential energy. Example response:

Car 1 has the most potential energy because it is higher on the ramp and therefore has more stored energy than Car 2.

Problem

Vehicle Restraint Design

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.

Included in Equipment Kit	Not Included in Equipment Kit	Device Applications
• Ramp (1 per class) • Eggs, plastic for design (1 per group) • Other materials as available such as rubber bands, cushion wrap, plastic wrap, pipe cleaners, tape, foil, and cotton balls (optional)	• Launch Log • Digital devices • VEX® IQ Construction or Robot Design Kit (1 per group) • Eggs, real for testing (1 per team plus extras if needed)	• Inkling • Mindomo • ShowMe Interactive Whiteboard • Camera • Slow motion video analysis, such as: ◦ SloPro (iPad®) ◦ Kapwing (Android Chrome OS)

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.
- 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.
- Explain, citing evidence, the relationship between the speed of an object and the energy of that object.
- Predict the transfer of energy as a result of a collision between two objects.
- Solve a simple design problem involving the transfer of energy and collisions between two objects.

ESSENTIAL QUESTIONS

EQ

1. How are potential and kinetic energy related?
2. What happens to energy during a collision?

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.
- 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: Vehicle Restraint Design

200 minutes

- In this design challenge, students will design a restraint system or alter the vehicle design to protect a passenger in a car during a collision. Students will prototype their design using the VEX IQ vehicle they constructed in Activity 3 and an egg as a passenger. The solution will be tested by rolling the vehicle down an inclined plane at varying slopes to evaluate the effectiveness of the design. Students will use technology to present their design solution, test outcomes, and provide suggestions for improvement.
- The teacher reads the fictional story of the friends from the Energy: Collisions Introduction and reminds students of the original design problem. Alternatively, students may read the introduction individually or in pairs.
- The students access the Problem: Vehicle Restraint Design assignment in the curriculum course.
- Optional: Guide students to view the Design Process video before you begin working through the problem.
- Design Process:

Ask

a. The teacher guides a discussion asking the students to again consider the problem.
b. The teacher reviews the design process and the role of engineers by reviewing step 2 of the procedure with the students.
c. The teacher reads through the criteria and constraints of the design problem as detailed in step 3 of the procedure.
d. The students review their entries in their Launch Logs and add information regarding the criteria and constraints.
e. The teacher guides the students how to complete the self-assessment at the end of the Ask section. The students circle one statement in each row.

Explore

a. The teacher leads the students through this step by following the directions found in step 4 of the procedure in the student course.
b. The teacher determines specific materials that may be used in the solution, including quantity of materials added to the vehicle and number of additional VEX IQ parts used. It is possible to create an effective design using only VEX IQ parts. Additional materials allowed are at the teacher's discretion.
c. Students are prompted to think about other restraint systems they may have seen including roller coasters and car seats. The teacher may suggest students research vehicle restraint systems on the internet. The design challenge may be completed successfully without additional research.

Model

a. The students design and model a system to protect a passenger in a car during a collision.
b. The teacher leads the students through this step by following the directions found in step 5 of the procedure.
c. Plastic eggs may be used by the students as they design their restraint system.
d. A decision matrix is used to compare possible design solutions. The decision matrix for students may be found on the document entitled Decision Matrix and may be printed for each student group.

Evaluate

1. The students collect and evaluate test data from the prototype vehicle restraint system. Step 6 of the procedure details how to test the prototypes.
2. If desired, the teacher may choose to increase the angle of the ramp by placing books or other objects under the top of the ramp. The teacher may then ask students to predict the resulting collision.
3. The students may use devices to record a video of the collision with the camera feature or a slow motion app such as SloPro. If using Chromebooks, students may capture the collision using the camera on the device and convert the video using Kapwing.

Explain

a. The students may use device apps such as Mindomo or ShowMe Interactive Whiteboard to present their design, an explanation of results, and suggestions for improvement.

- What materials did you choose for your model? Why did you choose them?
- How well did the chosen materials work?
- What can you do to improve your model?
- What was the most challenging part of the design process? Why do you think that?
- Explain how your team collaborated and communicated as you worked together.

b. An overview of this step is described in step 7 of the procedure.

- Disassemble the vehicle after the Problem is completed.
- Direct students to complete the Energy: Collisions 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 How well did your model protect the "passenger" in your testing? Use evidence from testing your model to explain your thinking.

Student responses will vary.

2 What changes would you make to improve the design?

Student responses will vary.

3 What is one way you could decrease the kinetic energy of the vehicle before it collides with the object at the end of the ramp?

Student responses should demonstrate an understanding of speed and kinetic energy. Example response:

To decrease the kinetic energy of the vehicle, I need to make it go slower. I could install additional VEX IQ parts onto the wheels of the vehicle that slow down the vehicle.

Introduction to the Module

Energy: Conversion

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: Energy: Conversion Teacher Guide.

PREFACE

Time: 10 instructional hours

Energy, and the conversion of energy to different forms, is all around you. Many of the devices we use every day convert electricity to usable forms of energy such as light and heat. Students learn about this conversion of energy as well as the conversion of a variety of fuel sources from stored energy to usable electrical energy.

First, students review concepts of potential and kinetic energy. Next, students learn about forms of energy including thermal, light, nuclear, chemical, electrical, and mechanical. Students then learn about the conversion of energy between forms and the energy transfer required to move energy from place to place.

After students have explored energy conversion and transfer, they are presented with a design problem involving moving large amounts of donated food from a truck to a food pantry.

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. Identify energy conversion in everyday situations.

UNDERSTANDINGS U

Students will understand that ...

1. Engineers have a step by step approach of looking at and solving 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 to develop after evaluating multiple possible designs.
5. Prototypes can be evaluated and improved upon using 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. Energy is the capacity to do work.
9. Energy has the ability to cause motion or create change.
10. Two types of energy exist: potential (stored energy) and kinetic (energy in motion).
11. Six main forms of energy include light, thermal, electrical, mechanical, chemical, and nuclear.
12. Energy can be converted from one form to another to meet a human need or want.
13. Energy can be transferred from place to place by sound, light, heat, and electric current.

KNOWLEDGE

K

It is expected that students will ...

- Explain what happens at each step of the design process.
- State questions engineers may ask when gathering information about a situation people want to change.
- Identify the differences between invention and innovation.
- List examples in which energy is converted between potential and kinetic energy.
- Describe six main forms of energy, including light, thermal, electrical, mechanical, chemical, and nuclear.
- List ways in which energy may be converted from one form to another.
- Describe how sound, light, heat, and electric current can transfer energy.

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.
- Differentiate between potential and kinetic energy.
- Explain how energy can be converted to meet a human need or want.
- Compare and contrast the transfer and conversion of energy.
- Apply scientific ideas about the conversion of energy to solve a simple design problem.
- Design a system that is able to store energy and then convert the energy to a usable form as it is released.

ESSENTIAL QUESTIONS

EQ

1. How are energy conversion and transfer related?
2. How can humans use energy conversion and transfer to meet needs and wants?
3. How is usable energy converted from resources in your area?
4. What are some energy conversions that take place to create usable energy in a community?

RESOURCES

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

Preparation

Note: In preparation for teaching this module, it is strongly recommended that the teacher read the Energy: Conversion 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.

In preparation for Activity 2, the teacher will need to build two electrical generators with the VEX® IQ equipment and additional supplies as described in Part 2.

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 app or browser cannot be used to view the steps, videos are available in the student course titled Bike Video Resource and Bike Pulley Video Resource. Direct students to use the video only if Fusion 360 is not accessible.

Note: There are two versions of the PLTW VEX IQ Construction Kit and PLTW VEX IQ Robot Design Kit. Either kit version may be used to construct the assemblies required for this module.

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 Energy: Conversion module, review the professional development resources.

- Access the **Launchpad** to review resources on the following:

- Instructional Approach
- Facilitation
- Launch Logs
- Navigating a Digital World with Students
- Implementation Planning
- Design Process Songs
- Creating Inclusive Classrooms
- Claims and Evidence

- Access the **Energy: Conversion Module-specific PD Resources** to review:
  - Energy: Conversion APB Overview
  - Building Your Understanding: Mechanical Energy
  - Building Your Understanding: Conservation of Energy Part 1
  - Building Your Understanding: Conservation of Energy Part 2
  - Building Your Understanding: Conservation of Energy Part 3
  - 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 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 **Fourth Grade Curriculum Revisions**.

Activity 1

What is Energy Conversion?

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.

Included in Equipment Kit	Not Included in Equipment Kit	Device Applications
• 16D nail (1 per class) • Rubber bands #32 (1 per student) • 5/16 – 18 x ¾" Machine bolts (1 per student) • 5/16 – 18 Nuts (3 per student) • Large paper clips (10) • Small paper clips (1 per student)	• Launch Logs (1 per student) • Digital devices • VEX® IQ Construction Kit or Robot Design Kit (1 per group) • Aluminum 12 oz. drink can (1 per student) • Cellophane tape (1 roll) • Hammer (1 per class) • Needle nose pliers (1 per class)	• Inkling • Mindomo • Internet browser for Fusion 360 links

RESOURCES

- Launch Log Grades 3-5
- PLTW VEX IQ Construction Kit Contents V1
- PLTW VEX IQ Construction Kit Contents V2
- PLTW VEX IQ Robot Design Kit Contents V1
- PLTW VEX IQ Robot Design Kit Contents V2
- VEX IQ Equipment List - Bike
- How to Access VEX IQ Assembly Instructions

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.
- List examples in which energy is converted between potential and kinetic energy.

ESSENTIAL QUESTIONS

EQ

1. How are energy conversion and transfer related?
2. How can humans use energy conversion and transfer to meet needs and wants?
3. How is usable energy converted from resources in your area?
4. What are some energy conversions that take place to create usable energy in a community?



SPRINGFIELD PUBLIC SCHOOLS

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113

Introduction Story

Community Food Pantry

Teacher Resources

View Student Course

RESOURCE

R

Introduction Story: Community Food Pantry

Time: 20 Minutes

Introduction

To set the stage for learning, guide students to read the Introduction Story: *Community Food Pantry*, 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: *Community Food Pantry*. 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 Energy Conversion?

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.

- The teacher leads a class discussion around the question of where to start when facing a challenge. The teacher reviews the design process and explains that the Launch Log will be used to record all work for this module, including brainstorming ideas, sketches, and other written work as assigned.
- In Part 1 students review potential and kinetic energy by searching the classroom for examples and documenting and sharing with the class. Prior to searching the classroom students view the **Energy Review** presentation through the curriculum course.
- Part 2 may be completed as a demonstration or as a student activity. The teacher and/or the students build a KinetiCan to demonstrate the conversion between kinetic energy to potential energy and back. **KinetiCan preparation instructions** can be found in the additional professional development resources. Student directions may be found in the KinetiCan presentation in the curriculum course.
- If the KinetiCan is to be built by the students, the teacher will need to collect a can for each student or pair of students to use for the construction.
- In Part 3 students reflect on human energy sources and how energy from food is converted to usable energy. The energy in food is stored as potential energy and is released as kinetic energy when converted for uses such as contracting muscles or generating heat.
- In Part 4 students construct a stationary bike model using the VEX IQ equipment. Students will use the Fusion 360 link to view instructions on how to construct the bike. One bike can be constructed from one kit.
- If this is the first time students will work with the VEX IQ equipment, the teacher may wish to allow students time to explore how the pieces fit together and how the kit is organized. The PLTW VEX IQ construction kit contents can be found in Activity 1 of this module.

> **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 bike.

- Students respond to questions in step 8 either as a discussion or in their Launch Logs.
- The bike assemblies will be used later in the Project and should remain intact to save time during that project if possible.

Activity 2

Energy Conversion in Action

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.

Included in Equipment Kit	Not Included in Equipment Kit	Device Applications
• Motors (2 per class) • Light Emitting Diodes, LED (2 per class) • Jumper leads (4 per class) • 8 Inch solid core wires (2 per class) • 4 Inch solid core wires (2 per class) • Hand warmers (6 per class) • Glow sticks (1 per student)	• Digital devices • Launch Logs • Parts from VEX® IQ Construction or Robot Design Kit to build a generator (2 per class)	• Inkling • Internet browser for Fusion 360 links • Mindomo • ShowMe Interactive Whiteboard

RESOURCES

VEX IQ Equipment List - Generator

How to Access VEX IQ Assembly Instructions

KNOWLEDGE AND SKILLS

KS

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

- Describe six main forms of energy, including light, thermal, electrical, mechanical, chemical, and nuclear.
- List ways in which energy may be converted from one form to another.
- Knowledge or Skill Share findings and conclusions with an audience.
- Differentiate between potential and kinetic energy.
- Explain how energy can be converted to meet a human need or want.

ESSENTIAL QUESTIONS

EQ

1. How are energy conversion and transfer related?
2. How can humans use energy conversion and transfer to meet needs and wants?
3. How is usable energy converted from resources in your area?
4. What are some energy conversions that take place to create usable energy in a community?

Activity 2: Energy Conversion in Action

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.

- In Activity 2: Energy Conversion in Action, students experience several types of energy conversion. As they work through the activity, they will be exposed to vocabulary that can be used in the final part of the activity.
- This activity is broken into three parts including a digital presentation created by the students. Part 1 of the activity will take approximately 30 to 40 minutes to complete.
- The teacher assists students in accessing the Energy: Conversion module in the app and leads a brief review of the design challenge faced by the three fictional students involving the food pantry design problem.
- Prior to students beginning Part 1 Energy Conversion Observations, the teacher will prepare two sets of three stations for the students to observe energy conversion. Students will observe each station for approximately 5-10 minutes.
- The generator station requires significant setup time by the teacher to build two hand crank generators as described below.

4.2 Generator



Generator video

- Student instructions for each station are located in Activity 2: Energy Conversion in Action.
- Specific station setup instructions are below:
  a. Hand Warmers
    - As student groups rotate through the station, they will open a hand warmer package, remove the hand warmer, and shake.
    - The station requires one hand warmer for each group. If all six stations are running at one time, both hand warmer stations will require three packages for a total of six in the classroom.
    - The hand warmers will begin to warm up as soon as they are exposed to air. To ensure students feel the change in temperature, each group will need to open a new package.
  b. Glow Sticks
    - All students will receive a glow stick at this station. Each station should have fifteen glow sticks for a class of thirty.
    - The students will be asked to bend the glow stick to break the glass tube in the middle.
    - If desired, the teacher may allow the students to take home the glow sticks.
  c. Generator

- Prior to this activity, the teacher will construct two identical generators to be used in the stations. Follow the directions shown in the **Generator** Fusion 360 link. One generator can be constructed from one kit.
- The generators are assembled from VEX IQ equipment, a motor, wires, jumper leads, motor, and LED.
- A typical LED illuminates when current flows in one direction and blocks current in the opposite direction, resulting in no illumination. The LED used in PLTW Launch is a specialized model known as a Bipolar LED or back-to-back LED. The LED is actually a combination of two LEDs with opposite polarity. Current in a direction results in the illumination of a green LED, while current in the opposite direction results in a red illumination. This is important to know if you acquire an LED from a source other than the PLTW kits or if a student recreates this activity outside of the classroom.
- If students cannot turn the generator handle fast enough to cause the LED to illuminate the generator, output can be increased by removing the 36 Tooth Gear and replacing it with a 60 Tooth Gear. This requires that the shaft be moved to the set of holes immediately above where it is shown in the Autodesk Inventor Publisher or Fusion 360 instructions. The increased power output from the generator increases the risk of damaging the LED, so modify only if needed.

- After the students complete their observations, they are prompted to reflect on the following questions:
  - What were some similarities between the stations?

    Teacher Only

    Possible responses include the following: glow stick and generator both created light; students had to do something to the glow stick and hand warmer for a change to occur.

  - What were some differences between the stations?

    Teacher Only

    Possible response includes the following: students needed to keep turning the generator, while the glow stick and hand warmer stayed lit and warm.

  - What do you think caused the changes you observed?

    Teacher Only

    Students may know that chemicals combine to make the glow sticks illuminate, and they may suggest that they made the LED illuminate when they turned the hand crank on the generator. The generator is an example of energy conversion from kinetic energy into electrical energy and then into light energy.

- The teacher will decide if the students record their answers in their Launch Logs or if they discuss the questions with a partner or small group. The teacher may also lead a class discussion using the questions.
- In Part 2 of the activity, students learn about six different forms of energy and review energy conversion. Part 2 of the activity will take approximately 20 minutes to complete. Students also view an **Energy** presentation in the curriculum course. Students may view the presentation individually, in pairs, or in small groups depending on the number of available devices.
- In Part 3 of the activity, students work in small groups to create a brief presentation describing the energy conversion in one of the stations. Part 3 of the activity will take approximately 60 minutes to complete. The student digital presentations should be simple. The teacher may decide how the information on energy conversion will be shared.
- The teacher decides if students will be assigned one of the three stations or if they will be allowed to pick a station of their choice.
- The students will use an app on the device either assigned by the teacher or chosen by the students to present their work. Possible apps include Mindomo or ShowMe Interactive Whiteboard.
- Expected answers:
  a. Hand Warmer: The energy conversion observed is chemical energy to thermal energy. This energy conversion meets a human need or want by providing heat for people in a cold setting.
  b. Glow Stick: The energy conversion observed is chemical energy to light energy. This energy conversion meets a human need or want by providing a source of light that can be turned on when desired.
  c. Generator: The energy conversion observed is mechanical energy from the person turning the hand crank to electric energy in the motor to light energy in the LED.
- Additional information on how each of the energy conversions occur is listed for teacher reference. Students do not need to understand the chemical reactions or electricity generation for the purposes of the activity. However, the teacher may wish to discuss the details of each conversion.
  a. Hand Warmer: The stored chemical energy is released as heat in an exothermic reaction that creates rust. A typical pouch will contain iron powder, salt, water, an absorbent material, and activated carbon. When the pouch is removed from the plastic packaging, the iron powder in the pouch reacts with oxygen in the air to form iron oxide.
  b. Glow Stick: There are two separate chemicals in the glow stick; one is inside a glass tube to keep the chemicals separated. When the glass inside breaks, the two chemicals can mix and a chemical reaction occurs. The chemicals in the glass are diphenyl oxalate plus a chemiluminescent dye. The chemical in the plastic tube is hydrogen peroxide. The chemical reaction that occurs results in chemiluminescence, or light created by a chemical reaction.
  c. Generator: The hand crank generator converts mechanical energy from the person turning the crank into electrical energy by spinning a coil of wire around a magnet. This electricity is then transferred to the LED and converted to light energy as the electricity passes through the LED.

- The students complete Activity 2 and answer Conclusion Questions in their Launch Logs.
- Disassemble the generator after part 2 is completed.

Activity 3

Light Up Your World

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.

Included in Equipment Kit	Not Included in Equipment Kit	Device Applications
• 3V batteries (1 per student pair) • Light Emitting Diodes, LED (1 per student pair) • Flashlights (1 per student pair)	• *The Boy Who Harnessed the Wind: Picture Book Edition by William Kamkwamba* (eBook) • Digital devices • Launch Logs	• Inkling • Kindle Cloud Reader • Mindomo • ShowMe Interactive Whiteboard • Internet Browser

KNOWLEDGE AND SKILLS

KS

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

- List ways in which energy may be converted from one form to another.
- Describe how sound, light, heat, and electric current can transfer energy.
- Explain how energy can be converted to meet a human need or want.
- Compare and contrast the transfer and conversion of energy.

ESSENTIAL QUESTIONS

EQ

1. How are energy conversion and transfer related?
2. How can humans use energy conversion and transfer to meet needs and wants?
3. How is usable energy converted from resources in your area?
4. What are some energy conversions that take place to create usable energy in a community?

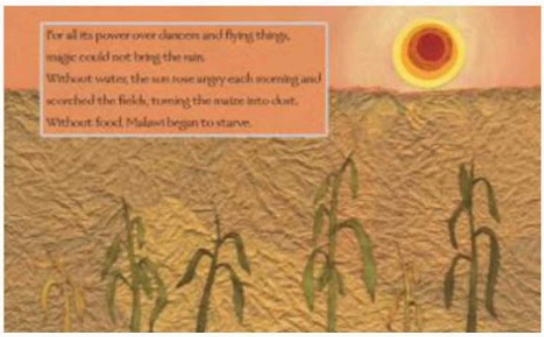
Activity 3: Light Up Your World

80 minutes

- This activity is designed to provide context for students learning about the sources of energy, its conversion into electrical energy, transporting energy to our homes and industry, and ultimately its conversion into forms of energy that benefit us, including light, thermal, and mechanical energy.
- The teacher reads *The Boy Who Harnessed the Wind: Picture Book Edition* by William Kamkwamba and leads a discussion with the students about why William was inspired to build his windmill. The teacher may wish to have the hand crank generator available for demonstration from Activity 2.
  The e-book may be projected from the teacher's device to allow the class to see the picture book. To make the text larger, double tap the text to make it pop up for easier reading as shown below:



Double tapping the image behind the text will return the screen to normal view with small text and full image as shown below:



Discussion questions may include:

a. Why did William build the windmill?
b. How did William "harness the wind"?
c. What are some similarities between William's windmill and the generator in Activity 2?

- The teacher assists the students in navigating to Activity 3: Light Up Your World in the app.
- In Part 1 of the activity, students will use a coin battery and LED to construct an electrical circuit. This will allow students to see an example of energy conversion from chemical energy into electrical energy then into light energy. The LED is the same LED used in the construction of the generator. Details about a bipolar, or back-to-back LED are in the section above. Students will use the knowledge gained by constructing a simple circuit to take apart a flashlight while documenting the energy conversions.
- In Part 2 of the activity, students apply what they learned from the previous circuits to learn about energy sources that generate large amounts of electricity for homes and businesses.
- Students work in pairs, small groups, or individually to research an energy source such as oil, natural gas, coal, or wind. Students organize and summarize this research by creating a mind map using Mindomo.
- If desired, students may complete the Going Further section of the activity and research the primary source of electricity in their community. Students may document their research using an app such as Mindomo or ShowMe Interactive Whiteboard, or they may create a resource to teach younger students about local energy production.
- Students answer Conclusion Questions in their Launch Logs.

Project

Harnessing Energy

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.

Included in Equipment Kit	Not Included in Equipment Kit	Device Applications
• String (48 inches per group)	• Digital devices • Launch Logs • VEX® IQ Construction Kit or Robot Design Kit (1 per group) • VEX IQ Bicycle built in Activity 1 (1 per group)	• Inkling • Internet browser for Fusion 360 links • Mindomo • ShowMe Interactive Whiteboard

RESOURCES

VEX IQ Equipment List - Bike Pulley

How to Access VEX IQ Assembly Instructions

LEARNING GOALS

By the end of this project, 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.
- List examples in which energy is converted between potential and kinetic energy.
- Differentiate between potential and kinetic energy.
- Explain how energy can be converted to meet a human need or want.
- Apply scientific ideas about the conversion of energy to solve a simple design problem.

ESSENTIAL QUESTIONS

EQ

1. How are energy conversion and transfer related?
2. How can humans use energy conversion and transfer to meet needs and wants?
3. How is usable energy converted from resources in your area?
4. What are some energy conversions that take place to create usable energy in a community?

Project: Harnessing Energy

80 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 assists the students in navigating to Project: Harnessing Energy in the app.
- The teacher reads through the introduction with the class and leads a short discussion on the tree house problem.
- In Part 1 students follow directions using the Fusion 360 link to build a pulley system using the VEX IQ equipment. One bike and one bike pulley can be constructed from one 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 bike pulley.

- In Part 2 students develop a solution for lifting objects into a tree house. Students will use the steps of the design process as outlined in the project and may choose to use the pulley and/or the bike from Activity 1 as part of their solution.
- Students document work in their Launch Logs, including all brainstorming, sketching, and testing information.
- The students complete Project: Harnessing Energy and answer the Conclusion Questions in their Launch Log.
- Disassemble the bike and bike pulley after the project is completed.

Problem

Food Pantry Design

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.

Not Included in Equipment Kit	Device Applications
• Digital devices • Launch Logs • VEX® IQ Construction Kit or Robot Design Kit • Other materials as available	• Inkling • Mindomo • ShowMe Interactive Whiteboard • Camera

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.
- List examples in which energy is converted between potential and kinetic energy.
- Describe six main forms of energy, including light, thermal, electrical, mechanical, chemical, and nuclear.
- List ways in which energy may be converted from one form to another.
- Describe how sound, light, heat, and electric current can transfer energy.
- 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.
- Differentiate between potential and kinetic energy.
- Explain how energy can be converted to meet a human need or want.
- Compare and contrast the transfer and conversion of energy.
- Apply scientific ideas about the conversion of energy to solve a simple design problem.
- Design a system that is able to store energy and then convert the energy to a usable form as it is released.

LEARNING GOALS

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.
- List examples in which energy is converted between potential and kinetic energy.
- Describe six main forms of energy, including light, thermal, electrical, mechanical, chemical, and nuclear.
- List ways in which energy may be converted from one form to another.
- Describe how sound, light, heat, and electric current can transfer energy.
- 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.
- Differentiate between potential and kinetic energy.
- Explain how energy can be converted to meet a human need or want.
- Compare and contrast the transfer and conversion of energy.
- Apply scientific ideas about the conversion of energy to solve a simple design problem.
- Design a system that is able to store energy and then convert the energy to a usable form as it is released.

ESSENTIAL QUESTIONS

EQ

1. How are energy conversion and transfer related?
2. How can humans use energy conversion and transfer to meet needs and wants?
3. How is usable energy converted from resources in your area?
4. What are some energy conversions that take place to create usable energy in a community?

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: Food Pantry Design

200 minutes

- In this design challenge, students will design and model a system to unload boxes of food at a community food pantry.
- The teacher reads the fictional story of the friends from the Energy: Conversions Introduction and reminds students of the original design problem.
- The students access the Problem: Food Pantry Design assignment on the app.
- Optional: Guide students to view the Design Process video before you begin working through the problem.
- Design Process

Ask

a. The teacher guides a discussion asking the students to again consider the problem.
b. The students review the criteria and constraints of the design problem by reading through step 3 in the procedure.
c. The teacher leads a discussion on the criteria and constraints of the design problem.
d. The students respond to the following questions in their Launch Logs:

- What is the need or want that we are trying to fulfill?
- What will make the design solution successful?

e. The teacher guides the students as they complete the self-assessment at the end of each section. The students circle one statement in each row.

Explore

a. The teacher leads the students through this step of the design process and encourages students to brainstorm several ideas before developing a single solution.
b. The teacher determines specific materials that may be used in the solution, including quantity of VEX IQ parts used and any additional materials as determined by the teacher.
c. The teacher guides the students through step 4 of the procedure.

Model

a. The students design and model a system to unload boxes of food at a community food pantry.
b. The teacher guides the students through the use of a decision matrix to compare possible design solutions. The decision matrix for students may be found on the document entitled Decision Matrix and may be printed for each student group.
c. Specific step-by-step instructions on how to use the Decision Matrix can be found in step 5 of the procedure.
d. The teacher guides the students as they complete the self-assessment at the end of each section. The students circle one statement in each row.

Evaluate

a. The students collect and evaluate test data.
b. The teacher may choose to have the student record a video of the test on a device.
c. Students record how well their system moved boxes of food a minimum of 12 inches.
d. Students may wish to build model food boxes using VEX IQ equipment or other materials.
e. The teacher guides the students as they complete the self-assessment at the end of each section. The students circle one statement in each row.

Explain

a. The students present their design, evaluation, and suggestions for improving their food box unloading system.
b. The students may use device applications such as Mindomo or ShowMe Interactive Whiteboard to present their design, an explanation of results, and suggestions for improvement.
c. The teacher guides the students as they complete the self-assessment at the end of each section. The students circle one statement in each row.

- Direct students to complete the Energy: Conversion Check for Understanding. You can access a printable version of this assessment in the Resources section of the **Summative Assessment** page.

Introduction to the Module

Input/Output: Computer 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: Input/Output: Computer Systems Teacher Guide.

PREFACE

Time: 10 instructional hours

In this module, students become computer scientists as they explore computing systems. Students learn that a computing system includes the computer hardware, software, and user. This system works together to process input and produce output. Students apply their understanding of computing systems as they compare them to human body systems.

Then, students explore how data are represented in computing systems. They learn that computers can only store 0s and 1s. To do this, computers use the binary system. Students learn that what they see on the screen is very different from what is stored inside a computer.

After building an understanding of computing systems, students create programs using a block-based coding language. Students follow the Use-Modify-Create Framework to write programs with sequences, events, loops, and variables. Applying skills and knowledge learned from the activities and project, students work together to design and program a digital game that keeps children busy while they are waiting.

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 technology to solve age-appropriate challenges by creating digital artifacts.

ESSENTIAL QUESTIONS

EQ

- EQ1 How does technology impact our lives?
- EQ2 In what ways do computing systems work together to accomplish tasks?
- 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 A computing system includes the computer hardware, software, and user. This system works together to process input and produce output.
- U3 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.
- 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	Understand how the parts of a computer work together to form a system.
LO3	Apply computational thinking strategies to understand and solve problems.
LO4.1	Apply mathematical thinking to solve problems.
LO4.2	Understand that programmers use the coordinate system to move objects.
LO5	Collaborate effectively on a diverse and multidisciplinary team.
LO6	Communicate effectively for specific purposes using the appropriate platform, tool, format, or digital media.
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	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.
KS2.1	Describe how internal and external parts of computing devices function to form a system. [CSTA 1B-CS-01]
KS2.2	Model how computer hardware and software work together as a system to accomplish tasks. [CSTA 1B-CS-02]
KS2.3	Model how computing systems break down input, process it, and produce output. [CSTA 1B-NI-04]
KS3.1	Organize and present collected data visually to highlight relationships and support a claim. [CSTA 1B-DA-06]
KS3.2	Use data to highlight or propose cause-and-effect relationships, predict outcomes, or communicate an idea. [CSTA 1B-DA-07]
KS3.3	Compare and refine multiple algorithms for the same task and determine which is the most appropriate. [CSTA 1B-AP-08]
KS3.4	Create programs that use variables to store and modify data. [CSTA 1B-AP-09]
KS3.5	Create programs that include sequences, events, loops, and conditionals. [CSTA 1B-AP-10]
KS3.6	Decompose (break down) problems into smaller, manageable subproblems to facilitate the program development process. [CSTA 1B-AP-11]
KS3.7	Apply a Use-Modify-Create approach to develop programming skills. [CSTA 1B-AP-12]
KS3.8	Use an iterative process to plan the development of a program by including others' perspectives and considering user preferences. [CSTA 1B-AP-13]
KS3.9	Test and debug (identify and fix) a program or algorithm to ensure it runs as intended. [CSTA 1B-AP-15]
KS3.10	Brainstorm ways to improve the accessibility and usability of technology products for the diverse needs and wants of users. [CSTA 1B-IC-19]
KS4.1.1	Make sense of problems and persevere in solving them. [CCSS.MATH.PRACTICE.MP1]
KS4.1.2	Reason abstractly and quantitatively. [CCSS.MATH.PRACTICE.MP2]
KS4.1.3	Model with mathematics. [CCSS.MATH.PRACTICE.MP4]
KS4.1.4	Use appropriate tools strategically. [CCSS.MATH.PRACTICE.MP5]
KS4.1.5	Look for and express regularity in repeated reasoning. [CCSS.MATH.PRACTICE.MP8]
KS4.2.1	Develop a basic understanding of the coordinate system.
KS4.2.2	Demonstrate the correct use of the coordinate system when moving objects in a block-based coding platform.
KS5.1	Generate ideas as a team.
KS5.2	Value the contributions of each team member.
KS5.3	Demonstrate collaboration through effective communication.
KS5.4	Collaborate with others while pair programming. [CSTA 1B-AP-16]
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.
KS7.1	Engage in and maintain positive interactions and relationships with other children and adults.
KS7.2	Engage in positive, safe, and legal behavior while using the internet and technology.



SPRINGFIELD PUBLIC SCHOOLS

ENGAGING STUDENTS • FOSTERING ACHIEVEMENT • CULTIVATING 21ST CENTURY GLOBAL SKILLS

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RESOURCES

R

- Curriculum Framework
- Connections to Standards
- Fourth Grade Connections to Standards
- Family Letter
- Additional Instructional Resources
- Fourth 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 Input/Output: Computer Systems 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
  - From Launch Logs to Engineering Notebooks
  - 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 **Input/Output: Computer Systems Module-specific PD Resources** to review:
  - Input/Output: Computer Systems APB Overview
  - Input/Output: Computer Systems 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.

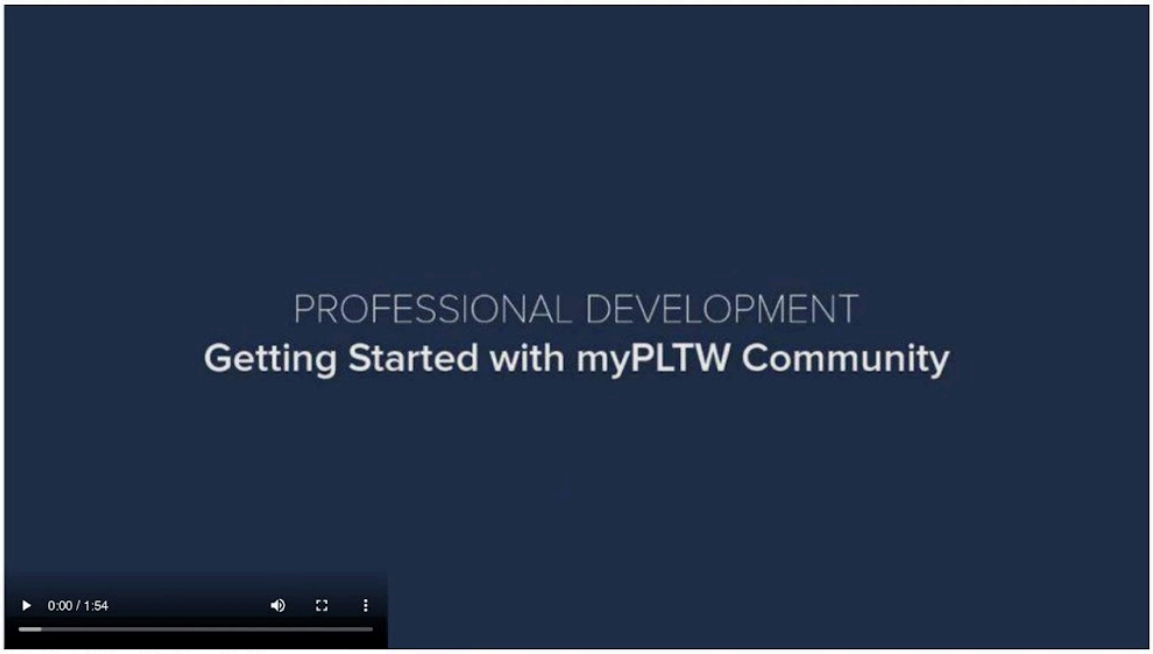
Building your questioning skills increases your capacity to facilitate powerful student learning. For more information, review the following professional development resources in the **Launchpad**:

- 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 Input/Output: Computer Systems module. To encourage career connections in the classroom, you could invite speakers, such as engineers, video game designers, analysts, and IT professionals, to talk about coding and computer science 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.

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 **Fourth Grade Curriculum Revisions**.

Each activity, project, and problem within this module is new. See **Input/Output: Computer Systems Updates** for more details.

Introduction Story

The Waiting Game

Teacher Resources

View Student Course

RESOURCE

R

Introduction Story: The Waiting Game

Time: 20 Minutes

Introduction

To set the stage for learning, guide students to read the Introduction Story: *The Waiting Game*, 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 Waiting Game*. 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

Inputs and Outputs

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) • Digital devices • Pencils or colored pencils for sketching • Chart paper • Markers	• Inkling • Chrome • Stopwatch

RESOURCES

R

Grades 3–5 Launch Log

Stay Safe and Secure!

ESSENTIAL QUESTIONS

EQ

EQ1 How does technology impact our lives?

EQ2 In what ways do computing systems work together to accomplish tasks?

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 Understand how the parts of a computer work together to form a system.

LO3 Apply computational thinking strategies to understand and solve problems.

LO5 Collaborate effectively on a diverse and multidisciplinary team.

LO6 Communicate effectively for specific purposes using the appropriate platform, tool, format, or digital media.

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.

KS2.1 Describe how internal and external parts of computing devices function to form a system. [CSTA 1B-CS-01]

KS2.2 Model how computer hardware and software work together as a system to accomplish tasks. [CSTA 1B-CS-02]

KS3.1 Organize and present collected data visually to highlight relationships and support a claim. [CSTA 1B-DA-06]

KS3.2 Use data to highlight or propose cause-and-effect relationships, predict outcomes, or communicate an idea. [CSTA 1B-DA-07]

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.

KS7.1 Engage in and maintain positive interactions and relationships with other children and adults.

KS7.2 Engage in positive, safe, and legal behavior while using the internet and technology.

Preparation

Professional Development

Before you facilitate Activity 1, access the **Input/Output: Computer Systems Module-specific PD Resources** to review:

- Computational Thinking
- Integrating Technology and Promoting Online Safety

Part 1. Computing Systems

1. Before you begin Activity 1, read the **Introduction Story: *The Waiting Game*** with students.
2. Before you begin Part 1, review the **Input and Outputs in Computing Systems** interactive experience to become familiar with how a computer processes input to produce output. Review the interactive experience on a student device to make sure it works.

> **Note for iPad Users**: This interactive experience works best in the Chrome browser. If your students use iPads with Safari as the default browser, show them how to open the interactive experience in the Chrome app. To learn how, view the How to Open an Asset in Chrome on an iPad presentation.



How to Open an Asset in Chrome on an iPad presentation

Part 2. Pass the Input

1. Before you begin Part 2, review the directions for the games, **Pass the Input (Shoulder)** and **Pass the Input (Ankle)**. If necessary, consider how to modify the games for students who have physical limitations.
2. Prepare a piece of chart paper titled "Pass the Input".

Input Type	Trial	Signal Travel Time (seconds)
Shoulder	1	
	2	
Ankle	1	
	2	

Part 3. Internet Safety

1. Before you begin Part 3, review the **Staying Safe and Secure** interactive experience.
2. If desired, print off the Stay Safe and Secure! resource for students to place in their PLTW Launch Logs.
3. Review the Procedure to become familiar with how your class will create a Code of Conduct for using the internet and social communication.
4. Review the sample Code of Conduct.

Code of Conduct Sample
• I will use strong passwords for my digital devices. • I will use strong passwords for my online accounts. • I will not share my password with anyone. • I will not write hurtful messages to others or treat them unkindly. • I will not share personal information on the internet. • I will immediately tell my teacher if I see something inappropriate while using the internet.

5. Prepare a piece of chart paper titled "Code of Conduct".

Time: 100 Minutes

Introduction

In this activity, students develop an understanding of computing *systems*. They watch an interactive presentation and explore how computers process *input* to produce *output*. In the presentation, students learn that computing systems are similar to human body systems. Students apply this understanding as they play a game to test their own reaction as they process input and produce output.

Many students use the internet, but do they know what the internet really is? Do they know how to stay safe while online? Do they know what information they should and should not share? Students explore the Staying Safe and Secure interactive experience to learn about internet safety. They learn how to use technology while maintaining digital privacy and security. They are introduced to the importance of engaging in positive, safe, and legal behavior while using the internet and social communication.

input	Data or information that is put into a machine or system.
output	Data or information that a machine or system produces.
system	A group of processes and parts that interact in a connected way.

Possible Student Misconceptions

- **Computers are magic boxes with thousands of tiny wires crammed inside**. The inside of a computer is very organized. Inside the smooth cases of digital devices are parts called hardware. Each part has a specific job to do. All the parts work together to make a system.
- **The internet and the world wide web are the same thing**. The internet is the connection of computer networks that allows us to access websites, or the world wide web (www). The internet is the infrastructure that supports the ability to send information from computer to computer all over the world. The world wide web is the way people connect with one another as they exchange and share information.
- **As long as I have a strong password, it is alright to share it with my friends**. It is important to have a strong password as well as to keep it private. You should never share a password with anyone.
- **I can put any information online because it is private**. This is not the case. The internet is worldwide, meaning that people all over the world are using it and have access to information that is posted. It is important to follow the classroom rules for using the internet. Following internet safety rules keeps you and others safe. Breaking the rules may have extreme consequences, such as committing a crime or keeping you from getting into a college or getting a job in the future.

Procedure

Part 1. Computing Systems

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. Introduce the **Inputs and Outputs in Computing Systems** interactive experience. Guide students to work with a partner or small group to scroll through the interactive experience to build an understanding of how a computer processes input to produce output.

   Notes:
   - In this experience, students scroll through the resource and listen to the audio as they read along silently.
   - In some scenes, students use drag and drop within a presentation.
   - Students use their PLTW Launch Log to record their work on inputs and outputs.

5. Lead a discussion about the presentation.

   - What types of information do we put into digital devices?
     Direct students to access the flashcard example as you introduce the vocabulary term *input*.
   - What types of information come out of digital devices?
     Direct students to access the flashcard example as you introduce the vocabulary term *output*.
   - How is a computing system similar to the human body system? Explain your thinking.
     Direct students to access the flashcard example as you introduce the vocabulary term *system*.
   - What do you think would happen if one part of the computing system was missing? Why do you think this?

6. Guide students to think of a machine that has at least one input and one output, such as:
   - Toaster
   - Smartphone
   - Car
   - Microwave
   - Alarm clock

7. Have students sketch the machine in their PLTW Launch Logs and label the inputs and outputs.
8. Direct students to share their sketches with a partner.
9. Lead a discussion about the machines.

- What input(s) did you identify on your machine?
- How do you know that is an input?
- What output(s) did you identify on your machine?
- How do you know that is an output?
- How do the parts of the machine work together as a system?

Part 2. Pass the Input

10. Introduce the game, Pass the Input. Explain how this game models how input moves through a system. Share with students that they will play two versions of this game—Pass the Input (Shoulder) and Pass the Input (Ankle).
Both versions of the game require a timekeeper. This person stands outside the circle and records how long it takes the input to move around the class. The timekeeper records the time of two trials for each game and writes the times for all to see on the Pass the Input table.
11. Guide students to create a table in their PLTW Launch Log to record the times.

Input Type	Trial	Signal Travel Time (seconds)
Shoulder	1	
	2	
Ankle	1	
	2	

12. Describe how to play the game, Pass the Input (Shoulder). In this game, students stand in a circle and face the back of another person. They place their right hand on the right shoulder of the person in front of them. When they feel a squeeze on their shoulder, they squeeze the shoulder of the person in front of them. See **Pass the Input (Shoulder)** for step-by-step directions.
13. Assign the timekeeper and lead the game based on the game directions.
14. Describe how to play the game, Pass the Input (Ankle). In this game, students stand in a circle and face the center of the circle. When they feel a squeeze on their left ankle, they bend down and squeeze the left ankle of the person next to them. See **Pass the Input (Ankle)** for step-by-step directions.
15. Assign the timekeeper and lead the game based on the game directions.
16. Lead a discussion about the game.

- In Pass the Input (Shoulder), what was the input? What was the output?

  In Pass the Input (Shoulder), the input was the squeeze I felt on my shoulder. The output was my hand squeezing the next person's shoulder.

- In Pass the Input (Ankle), what was the input? What was the output?

  In Pass the Input (Ankle), the input was the squeeze felt on my ankle. The output was my hand squeezing the next person's ankle.

- Which version took longer to pass the input? Why do you think this?
- Do you think computing systems or human body systems are able to process input faster? Why do you think this?

Part 3. Internet Safety

17. 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.

18 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.

19 Guide students to work with their partner or small group to brainstorm guidelines they should follow while using the internet. Students should use what they learned from the Staying Safe and Secure interactive experience and record their ideas in their PLTW Launch Logs.

20 Have students share their ideas with the class. Explain that as a class, they will create a Code of Conduct for how they think they should behave while using the internet. As a class, choose which guidelines should be adopted. Record the chosen rules using "I will" statements on the "Code of Conduct" chart paper. Post the Code of Conduct in the classroom where students can easily view it.

21 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 PLTW Launch Logs.

1 A calculator is a type of computing system. Describe the input and output of a calculator.

Student responses should demonstrate an understanding of inputs and outputs. Example response:
The user provides input when they press the buttons on a calculator. The numbers displayed on the calculator's screen are an example of output.

2 Why is it important to engage in positive, safe, and legal behavior while using the internet? Explain your thinking.

Student responses should demonstrate an understanding of digital citizenship. Example response:
The internet connects us to others. There are strangers of all ages using the internet. By staying safe and treating others with respect, the internet becomes a better place.

Activity 2

Information Highway

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) • Digital devices • Pencils or colored pencils for sketching • Chart paper • Markers	• Inkling • ShowMe Interactive Whiteboard

RESOURCES

R

Code Intelligence

Image Decoder

ESSENTIAL QUESTIONS

EQ

EQ1 How does technology impact our lives?

EQ2 In what ways do computing systems work together to accomplish tasks?

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 Understand how the parts of a computer work together to form a system.

LO4.1 Apply mathematical thinking to solve problems.

LO5 Collaborate effectively on a diverse and multidisciplinary team.

LO6 Communicate effectively for specific purposes using the appropriate platform, tool, format, or digital media.

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.

KS2.3 Model how computing systems break down input, process it, and produce output. [CSTA 1B-NI-04]

KS3.2 Use data to highlight or propose cause-and-effect relationships, predict outcomes, or communicate an idea. [CSTA 1B-DA-07]

KS4.1.3 Model with mathematics. [CCSS.MATH.PRACTICE.MP4]

KS4.1.4 Use appropriate tools strategically. [CCSS.MATH.PRACTICE.MP5]

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.

KS7.1 Engage in and maintain positive interactions and relationships with other children and adults.

KS7.2 Engage in positive, safe, and legal behavior while using the internet and technology.

Preparation

Part 1. Data Representation

To become familiar with the content, preview the Data Representation resource in the student course. Review the discussion questions in the Procedure.

Part 2. Text Representation

1. Prepare a piece of chart paper titled "How to Write in Binary." Another option is to create the chart using the ShowMe Interactive Whiteboard app and project the chart for students to see.

Symbol	Binary

2. Find the Code Intelligence activity sheet in Resources. Print one Code Intelligence activity sheet for each student. Preview the document to become familiar with the instructions and how students will decode messages.
3. Decode all messages on the Code Intelligence activity sheet to help you facilitate this part.

Part 3. Image Representation

1. To become familiar with the content, preview the Image Representation resource in the student course. Review the discussion questions provided in the Procedure.
2. Find the Image Decoder activity sheet in Resources. Print one Image Decoder activity sheet for each student. Preview the document sheet to become familiar with the instructions and how students will use Run Length Encoding.

Time: 90 Minutes

Introduction

In this activity, students discover how data are represented in a computing *system*. They also learn about the difference between information that people understand, encoded data that a computer can understand, and how computers translate from one to the other.

input	Data or information that is put into a machine or system.
output	Data or information that a machine or system produces.
system	A group of processes and parts that interact in a connected way.

Procedure

Part 1. Data Representation

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 are some examples of input that we put into digital devices? How do you know that is input?
  Direct students to access the flashcard example as you review the vocabulary term *input*.
- What are some examples of output that digital devices produce? How do you know that is output?
  Direct students to access the flashcard example as you review the vocabulary term *output*.
- What is a computing system?
  Direct students to access the flashcard example as you review the vocabulary term *system*.
- What do you think would happen if one part of the computing system was missing? Explain your thinking.
- Why is it important to follow a Code of Conduct while using the internet?
- What should you do if someone asks for your password(s) or bullies you online?

4. Guide students to work with a partner or small group to read the Data Representation resource in the student course. In this resource, students learn that computers store information in binary (1s and 0s). A computer is programmed to constantly convert any input to its binary value so that it can be processed or stored. Any output a computer produces is also converted from binary to a form that humans can read and understand.

5. Lead a discussion on data representation.

- What type of information can people store in their brains?

  People store lots of information in their brains. Examples include letters, numbers, pictures, and music.

- How are computers different? What values can they store?

  Computers can only store combinations of 0s and 1s. They cannot store other digits, such as 2, 3, 4, 5, 6, 7, 8, or 9. Also, computers cannot store letters.

- What happens to input as it enters a computing system?

  As input enters a computing system, it is converted to 0s and 1s.

- A bit is short for binary digit. How is a bit different than a byte?

  A bit can only hold two possible values: 0 and 1. A byte can hold 8 bits.

Part 2. Text Representation

6. Share with students that because binary is hard for humans to read, computer scientists came up with a way to represent all basic information that can be entered into a computer. There are multiple formats used today, but the most commonly used format is called ASCII, which stands for American Standard Code for Information Interchange.

7. Guide students to view the ASCII Table to see how letters and numbers are represented.

8. Model how to write "PLTW" in binary.

Symbol	Binary
P	01010000
L	01001100
T	01010100
W	01010111

9. Allow time for students to practice writing in binary. Have them write their first name in binary in their PLTW Launch Logs. Guide students to use a table like the one above.

10. Hand out a copy of the Code Intelligence activity sheet to each student.

11. Guide the students to use the ASCII table to:
    - Decode a message written in numbers
    - Decode a message written in binary

- Write a secret message in binary

Note: Guide students to write their secret message in a table. This makes it easier to decode. Sample table:

Binary	Symbol

12 Have students exchange their secret message with another student and try to decode each other's messages.

13 Lead a discussion on text representation.

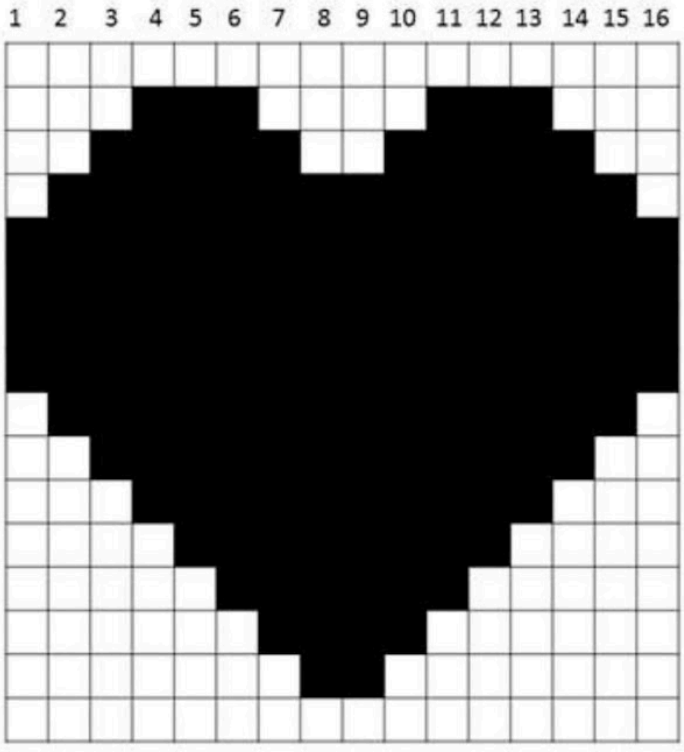
- Is it easier for you to read words in binary or letters? Why do you think this?
- Think about how long it took you to decode your partner's secret message. How would this time change if a computer decoded it? What makes you think this?

Part 3. Image Representation

14 Guide students to work with a partner or small group to read the Image Representation resource in the student course. In this resource, students learn how images are stored on a computer.

15 Hand out a copy of the Image Decoder activity sheet to each student and have them read the Introduction.

16 Model how to encode an image using Run Length Encoding.



White, Black, White...

16, 0
3, 3, 4, 3, 3
2, 5, 2, 5, 2
1, 14, 1
0, 16
0, 16
0, 16
0, 16
1, 14, 1
2, 12, 2
3, 10, 3
4, 8, 4
5, 6, 5
6, 4, 6
7, 2, 7
16, 0

> **Note**: Each row in the bitmap must begin with the number of white pixels followed by the number of black pixels. If the row starts with a black pixel, then the encoding of the row should start with a 0, representing the number of leading white pixels to be 0.

17 Guide the students to:

- Fill in the appropriate squares to draw a picture on the 16 x 16 grid.
- Use Run Length Encoding to encode their picture.
- Exchange their Run Length Encoding with another student.
- Fill in the appropriate squares to decode their partner's Run Length Encoding.

18 Lead a discussion on image representation. Below each question, you find additional information to share with students.

- What did you notice about the edges of your picture?

  The edges of my picture are all horizontal and vertical lines. There are no curves. All of the lines meet at square corners.

  > **Note**: As students colored their picture, they were not able to color in a fraction of a square. They had to color the entire square. The squares, or pixels, on the 16 x 16 grid were large. This results in square edges.

- Do images on digital devices look like the images you created? Why do you think this?

  No, the images on digital devices do not look like what I drew. The images on digital devices have smooth edges. I think my image had rough edges because the grid was large.

  > **Note**: The pixels on digital devices are much smaller than the pixels on our grid. This allows us to see crisp, clear images.

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

Conclusion Questions Answer Key

1 Think about Run Length Encoding. Were you able to color in half of a square? Explain your answer.

Student responses should demonstrate an understanding of Run Length Encoding. Example response:
You cannot color in half a square when you encode a picture using Run Length Encoding. Each number represents either a 0 or a 1. There is no way to represent a fraction of a square.

2 It took you some time to encode a picture into numbers, and it took your partner some time to decode the picture and recreate it. Why do you think encoding and decoding is a slow process for humans but a very quick process for computers?

Student responses should demonstrate an understanding of computing systems. Example response:
Computers process all information as 0s and 1s which can move through the computer very quickly as electrical signals. Humans do not process information with transistors and electricity, so it takes us longer to complete work.

Activity 3

Inputs and Outputs in Computer Programming

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) • Digital devices • Pencils or colored pencils for sketching	• Inkling • Scratch (Before signing in, see Preparation for registration information.)

ESSENTIAL QUESTIONS

EQ

EQ1 How does technology impact our lives?
EQ2 In what ways do computing systems work together to accomplish tasks?
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 Apply computational thinking strategies to understand and solve problems.
LO4.1 Apply mathematical thinking to solve problems.
LO5 Collaborate effectively on a diverse and multidisciplinary team.
LO6 Communicate effectively for specific purposes using the appropriate platform, tool, format, or digital media.
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.
KS3.2 Use data to highlight or propose cause-and-effect relationships, predict outcomes, or communicate an idea. [CSTA 1B-DA-07]
KS3.5 Create programs that include sequences, events, loops, and conditionals. [CSTA 1B-AP-10]
KS3.7 Apply a Use-Modify-Create approach to develop programming skills. [CSTA 1B-AP-12]
KS3.8 Use an iterative process to plan the development of a program by including others' perspectives and considering user preferences. [CSTA 1B-AP-13]
KS3.9 Test and debug (identify and fix) a program or algorithm to ensure it runs as intended. [CSTA 1B-AP-15]
KS4.1.2 Reason abstractly and quantitatively. [CCSS.MATH.PRACTICE.MP2]
KS4.1.4 Use appropriate tools strategically. [CCSS.MATH.PRACTICE.MP5]
KS5.1 Generate ideas as a team.
KS5.2 Value the contributions of each team member.
KS5.3 Demonstrate collaboration through effective communication.
KS5.4 Collaborate with others while pair programming. [CSTA 1B-AP-16]
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.
KS7.1 Engage in and maintain positive interactions and relationships with other children and adults.
KS7.2 Engage in positive, safe, and legal behavior while using the internet and technology.

Preparation

Professional Development

Before you facilitate Activity 3, access the **Input/Output: Computer Systems Module-specific PD Resources** to review:

- Computational Thinking
- Building Computational Thinking with Young Children
- Use-Modify-Create Framework

Part 1. Introduction to Scratch

> **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.

4. Preview the Scratch **tutorials**. Decide which ones are appropriate for your students based on their previous Scratch experience.

Suggested tutorials for students who are new to Scratch:	Suggested tutorials for students with Scratch experience:
• Getting Started • Add a Backdrop • Add a Sprite • Animate a Character • Change Size	• Make It Fly • Glide Around • Make It Spin • Hide and Show • Add Effects • Record a Sound

5. Become familiar with the Scratch interface. Click the information icons in the image to become familiar with names of the user interface areas.



Scratch Interface image

6. Create a few sample programs with the given criteria so you can better facilitate this activity with students.

Time: 90 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. Then, they use their creativity to write a program to animate a sprite.

bug	An error in a computer program that causes the program to run incorrectly.
debug	To find and fix bugs in a program.
driver	The person who controls the device during pair programming.
input	Data or information that is put into a machine or system.
navigator	The person who watches closely, makes suggestions, and asks/answers questions during pair programming.
output	Data or information that a machine or system produces.
pair programming	When two people work together to create a computer program.

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 Scratch

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 Activity 2.

- How do computers store information?
- How is this different from the way people store information?
- What did you learn about binary values?
- Would you want to read and write in binary? Why or why not?
- How are images displayed on electronic screens?

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.



Pair Programming video

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 example 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

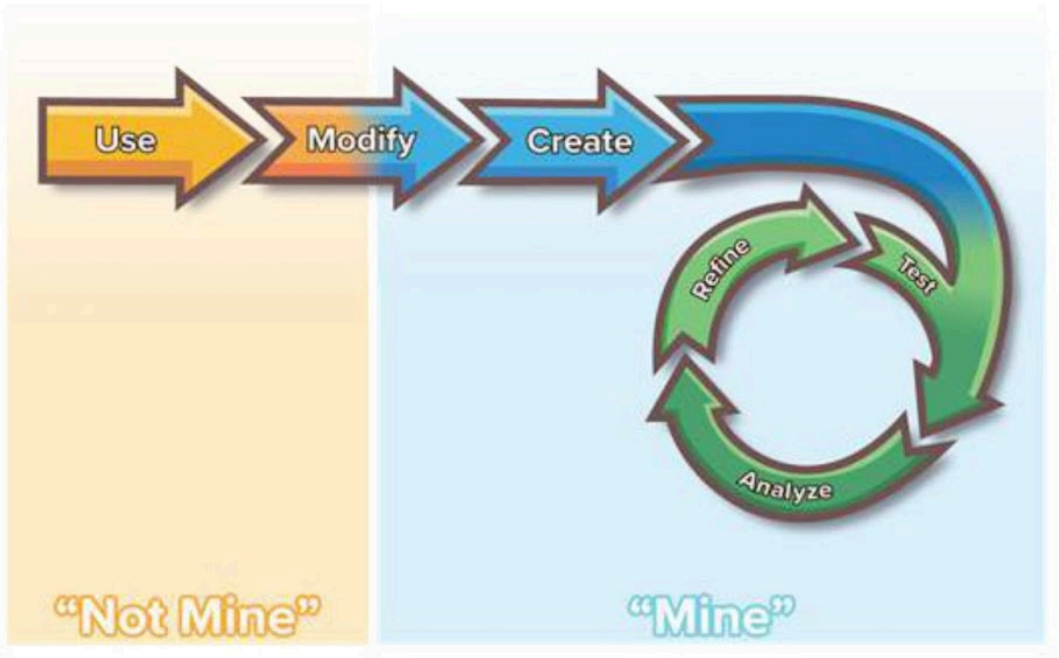
7 Provide students their usernames and passwords so they can log in to **Scratch**.

8 After students log in, direct them to select **Create**. When students go to the website, the tutorial screen automatically opens. For now, have the students close the tutorial window.

9 Allow the students 10 minutes 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. To view the tutorials, guide students to select **Tutorials** on the menu bar. Of the many tutorials for students to view, select the ones that are most appropriate for your students based on their previous Scratch experience.

Suggested tutorials for students who are new to Scratch:	Suggested tutorials for students with Scratch experience:
• Getting Started • Add a Backdrop • Add a Sprite • Animate a Character • Change Size	• Make It Fly • Glide Around • Make It Spin • Hide and Show • Add Effects • Record a Sound

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(s)
  - The size of the sprite
  - Backdrop
- Students can refer to these tutorials at any time throughout the module.
- If you think your students need a more guided experience, walk them through how to add a backdrop, add a sprite, program the sprite, and change its size.
- Allow time for student groups to collaborate, so they can teach each other how to add a backdrop, add a sprite, program the sprite, 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*.
- Think about the programs you created in the tutorials. What was the input? What was the output?
  Direct students to access the flashcard examples as you review the vocabulary terms *input* and *output*.

> **Note**: In Activity 1, students learned about inputs and outputs in a computing system. A computing system includes the computer hardware, software, and user. The keyboard, mouse, speaker, and camera are examples of computer hardware.
>
> Scratch is an example of computer software. In Scratch, the coding blocks are considered input. The actions of the sprite(s) are considered output.
>
> Programs may also require keyboard or mouse input from the user. For example, if the students wrote a program with the "when green flag clicked" block, the input is when the user clicks or taps the green flag. The output is the program that runs.

Part 2. Animate a Sprite

15 Guide students to work with their group to write a program to animate a sprite. Encourage students to use what they learned in the tutorials to create a new program. Students may want to review the tutorials to help them complete this task. Remind students of some of the ways to animate a sprite, such as:

- Grow and shrink
- Disappear and reappear
- Jump up and down
- Change costumes
- Spin
- Glide

16 Have students work with their partner or group to create a plan for their program. The plan should include:

- Sprite(s)
- Backdrop
- Actions of the sprite(s)
- Ideas about how to program the sprite(s) to complete the action

17 Guide students to give their program a meaningful name. An example is "Animate a Sprite Group 1."



18 Have students type the program name in the box and select **File**. Then select **Save Now**.

19 Allow students about 15 minutes to write a program to animate a sprite.

> **Note**: It is normal and expected that programs do not work exactly as intended at first. Encourage students to iterate and fix errors while programming.

20 At the end of this time, have students share their programs with the class. If possible, project the digital device screens with the programs so all students can view them. Guide students to:

- Discuss which blocks they chose to animate the sprite
- Identify the inputs and outputs of their program

21 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*.

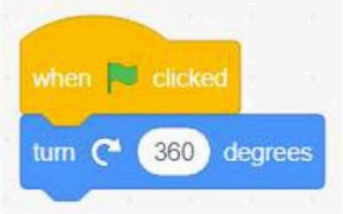
22 Guide students to answer the Conclusion Questions. Lead a discussion for students to share their thoughts.

Conclusion Questions Answer Key

1 What did you learn about programming from viewing other students' programs? What would you like to include in future programs?

Student responses will vary.

2 Take a look at this basic program. What input is required to start the program? What output can you expect? Explain your thinking.



Student responses should demonstrate an understanding of inputs and outputs. Example response:
With this program, the user clicks the green flag to start the program. This is an example of input. Input is the data or information put into a machine or system. When the user clicks the green flag, it triggers the program to start.

The output is the data or information that a machine or system produces. In this program, the sprite turns 360 degrees when the user clicks the green flag.

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 good practice to use 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

Creative Coding

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) • Digital devices • Pencils or colored pencils for sketching	• Inkling • Scratch

ESSENTIAL QUESTIONS

EQ

EQ1 How does technology impact our lives?
EQ2 In what ways do computing systems work together to accomplish tasks?
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 Apply computational thinking strategies to understand and solve problems.
LO4.1 Apply mathematical thinking to solve problems.
LO4.2 Understand that programmers use the coordinate system to move objects.
LO5 Collaborate effectively on a diverse and multidisciplinary team.
LO6 Communicate effectively for specific purposes using the appropriate platform, tool, format, or digital media.
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.
KS3.2	Use data to highlight or propose cause-and-effect relationships, predict outcomes, or communicate an idea. [CSTA 1B-DA-07]
KS3.3	Compare and refine multiple algorithms for the same task and determine which is the most appropriate. [CSTA 1B-AP-08]
KS3.4	Create programs that use variables to store and modify data. [CSTA 1B-AP-09]
KS3.5	Create programs that include sequences, events, loops, and conditionals. [CSTA 1B-AP-10]
KS3.6	Decompose (break down) problems into smaller, manageable subproblems to facilitate the program development process. [CSTA 1B-AP-11]
KS3.7	Apply a Use-Modify-Create approach to develop programming skills. [CSTA 1B-AP-12]
KS3.8	Use an iterative process to plan the development of a program by including others' perspectives and considering user preferences. [CSTA 1B-AP-13]
KS3.9	Test and debug (identify and fix) a program or algorithm to ensure it runs as intended. [CSTA 1B-AP-15]
KS4.1.2	Reason abstractly and quantitatively. [CCSS.MATH.PRACTICE.MP2]
KS4.1.4	Use appropriate tools strategically. [CCSS.MATH.PRACTICE.MP5]
KS4.1.5	Look for and express regularity in repeated reasoning. [CCSS.MATH.PRACTICE.MP8]
KS4.2.1	Develop a basic understanding of the coordinate system.
KS4.2.2	Demonstrate the correct use of the coordinate system when moving objects in a block-based coding platform.
KS5.1	Generate ideas as a team.
KS5.2	Value the contributions of each team member.
KS5.3	Demonstrate collaboration through effective communication.
KS5.4	Collaborate with others while pair programming. [CSTA 1B-AP-16]
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.
KS7.1	Engage in and maintain positive interactions and relationships with other children and adults.
KS7.2	Engage in positive, safe, and legal behavior while using the internet and technology.

Preparation

For students to create the clicker game successfully, several skills need to be developed. In this project, students develop knowledge and skills in Parts 1 and 2. Then they apply their learning in Part 3.

Part 1. Coordinate System

1. Review the information in the Procedure about the coordinate grid. Scratch uses the coordinate system to move sprites around the stage. Students need to have an understanding of the coordinate system as they create more complex programs.
2. Consider your students' current understanding of the coordinate system. As you review the procedure steps, determine additional support your students may need to grasp these concepts.
3. To become familiar with the content, preview the Coordinate System presentation in the student course. Review the discussion questions in the Procedure.

Part 2. How to Make a Clicker Game

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. Watch the Make a Clicker Game tutorial in Scratch to prepare for Part 2. Interact with the tutorial to create the clicker game.
3. As your students explore Scratch, they will naturally begin to take a deeper dive 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. Be comfortable with your students if they move beyond what you know about creating programs in Scratch.

Part 3. Create Your Own Clicker Game

Create your own clicker game in Scratch. This helps you to facilitate the project with students and understand the challenges they may face.

Time: 120 Minutes

Introduction

In this project, students deepen their understanding of how to move a sprite on the stage. They are introduced to the *coordinate grid*. Your students use the coordinate grid to move sprites to specific locations.

Then, students view a tutorial to learn how to make a clicker game. Students follow the Use-Modify-Create Framework to create their own clicker game that requires user *input*.

bug	An error in a computer program that causes the program to run incorrectly.
coordinate grid	A grid made up of vertical and horizontal lines and points that can be identified by their x-coordinate (the distance from the y-axis) and their y-coordinate (the distance from the x-axis).
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.
debug	To find and fix bugs in a program.
driver	The person who controls the device during pair programming.
event	An action that causes the program to react in a certain way.
input	Data or information that is put into a machine or system.
loop	A programming element that repeats a set of code.
navigator	The person who watches closely, makes suggestions, and asks/answers questions during pair programming.
output	Data or information that a machine or system produces.
pair programming	When two people work together to create a computer program.
program	A set of code given to a computer to accomplish a task.
variable	Something that changes or can be changed.

Procedure

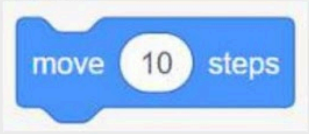
Part 1. Coordinate System

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*.
- Describe the roles of the driver and navigator while pair programming.
  Direct students to access the flashcard examples as you review the vocabulary terms *driver* and *navigator*.
- 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*.

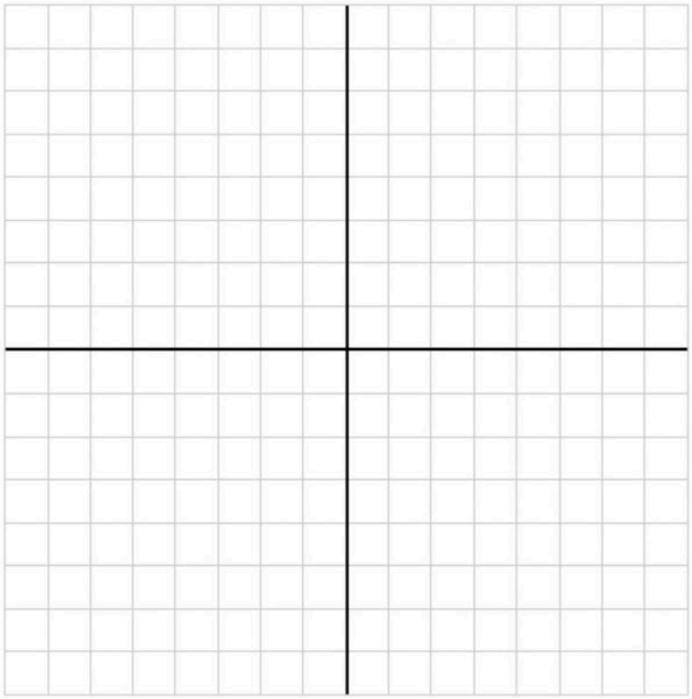
4. In Scratch, there are different ways to program a sprite to move. Lead a discussion about how to program a sprite to move. Guide students to think about what they learned in the tutorials in Activity 3.

- What happens when you use this code block in a program?



- How can I use the same code block to get a sprite to move to the left?
- Do you think there are other ways to get a sprite to move left or right? Use evidence to support your thinking.

5. Explain to students that Scratch uses a coordinate system in which characters can be identified by their x- and y-coordinates. Direct students to access the flashcard example as you introduce the vocabulary term *coordinate grid*.
6. Draw a coordinate grid on the board or display the image below to demonstrate the positive and negative numbers along the axes.



Coordinate Grid

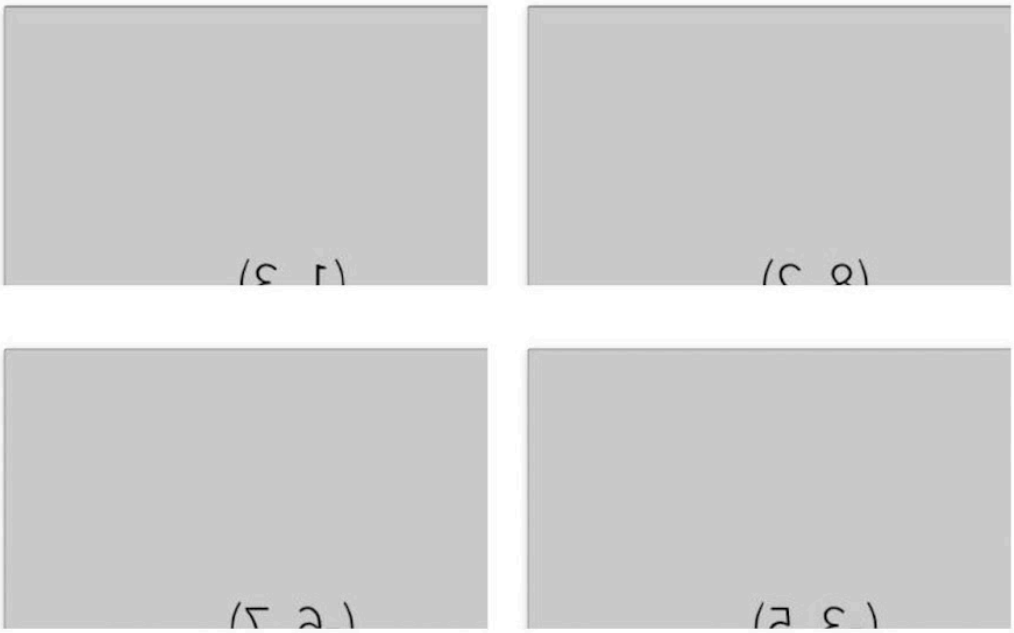
7 Introduce the coordinate grid to your students.

- Explain that the horizontal axis is called the x-axis and that the vertical axis is called the y-axis.
- Share with students that with a coordinate grid, you can locate any point based on their x- and y-coordinates.
- Explain that an ordered pair is a set of two numbers with the x-coordinate listed first and the y-coordinate listed second.
- Demonstrate how to correctly write an ordered pair: (x, y).
- Explain how to use the coordinates:
  - The x value indicates how to move along the horizontal x-axis. This number tells you whether to move right or left.
  - The y value indicates how to move along the vertical y-axis. This number tells you whether to move up or down.

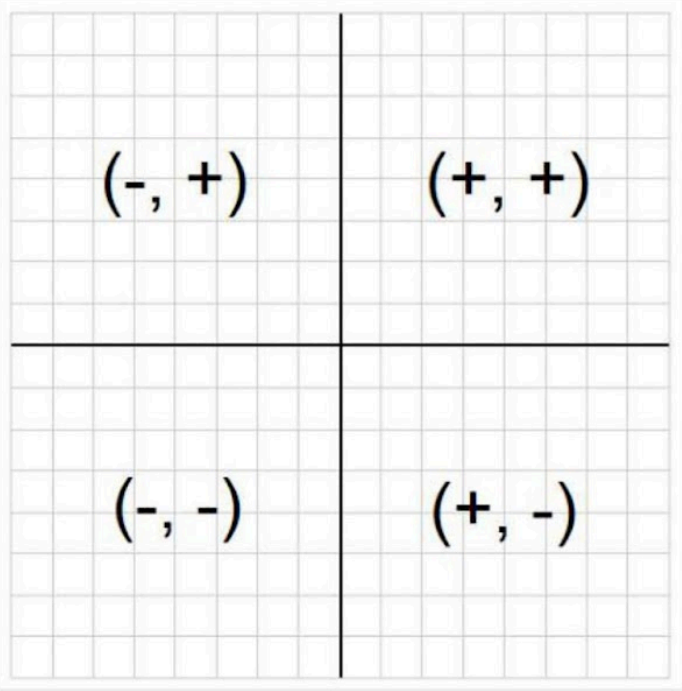
8 Demonstrate how to find a specific coordinate—(4, -5):

- Start at (0, 0).
- Since the first number is positive, count four spaces to the right on the horizontal x-axis.
- Since the second number is negative, count down (vertically) five spaces.
- Draw a point at (4, -5)

9 Model how to find the coordinates of the ordered pairs (1, 3), (8, -2), (-6, -7), and (-3, 5). Demonstrate how to turn the flashcard over to check your answers.



Note: For this module, it is not important for students to have a thorough understanding of the coordinate grid. To use the coordinates within several programming blocks, they need to have an idea of which quadrant an ordered pair falls in.



10 Guide students to work with a partner to determine the ordered pair of two points on a coordinate grid in the student course. Monitor students as they work, providing guidance as needed. Have the students share their thoughts with each other about how they determined the ordered pair for each image.

11 Direct students to drag and drop four ordered pairs to the correct location on a coordinate grid. As students work with their partner, circle around the room and assess students' progress in locating the ordered pair on the grid. Ask students to share their ideas and thinking with you as they work. As

you uncover misconceptions, work with students to build an accurate conceptual understanding.

12. Lead a discussion about the coordinate grid.

- How did you determine the ordered pair for each image?
- Look at each quadrant, or section, of the coordinate grid. What patterns do you notice about the location of ordered pairs? Explain your thinking.

Note: As you formatively assess your students' understanding of using the coordinate grid, be prepared to add additional practice as needed.

13. 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.

14. Guide students to work with a partner or small group to view the Coordinate System presentation in the student course.

15. Lead a discussion about the coordinate system.

- How do you use the coordinate grid in programming? Use evidence to support your thinking.
- If you want a sprite to move to the upper left corner of the stage, how would you do that?
- If you want a sprite to move to the lower right corner of the stage, how would you do that?

Part 2. How to Make a Clicker Game

16. Guide students to think back to the game, Pass the Input in Activity 1. Lead a discussion about the input and output of the game.

- What was the input? How do you know that is input?
  Direct students to access the flashcard example as you review the vocabulary term *input*.
- What was the output? How do you know that is output?
  Direct students to access the flashcard example as you review the vocabulary term *output*.
- Do you think there is a way to create a program in Scratch where the user triggers the sprite to do something? How do you think this can be done?

17. Explain to students that Scratch uses Event blocks to trigger different actions. Direct students to access the flashcard example as you introduce the vocabulary term *event*.

18. Guide students to select the **Events** blocks category in Scratch to view the different blocks.

19. Lead a discussion about these blocks.

- Which of these blocks have you used in your programs?
- How did you use them?
- What happened in your program when you used an Event block?
- Are Event blocks are an example of input or output? Why do you think that?

  Event blocks are an example of input. The Event blocks trigger an action to occur. The trigger is input from the user or program, such as when:
  - The green flag is clicked.
  - A specific key is pressed.
  - A sprite is clicked.
  - The backdrop switches.

20. Have students work with a partner or small group to interact with the Make a Clicker Game tutorial. Guide students to:
- Select **Tutorials** on the menu bar.
- Select **Make a Clicker Game**.

21. As students interact with the tutorial, remind them to:
- View the video first. Then use the slides as they 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.

22 Lead a discussion about the tutorial.

- What is the input in the clicker game? How do you know that is input?
- What is the output in the clicker game? How do you know that is output?
- How did you program the game to keep score?
  Direct students to access the flashcard example as you introduce the vocabulary term *variable*.
- How did you program the sprite to keep moving around the stage?
  Direct students to access the flashcard example as you introduce the vocabulary term *loop*.

Part 3. Create Your Own Clicker Game

23 Guide students to work with their group to write a program to make their own clicker game. Encourage students to use what they learned in the tutorial to create a new program.

24 Explain that to create their programs, students need to follow the *criteria* and *constraints*. Use the flashcard examples as you introduce or clarify the vocabulary terms *criteria* and *constraint*.

25 Introduce the criteria and constraints of the program.

Criteria	Constraints
The program: • Includes a sprite(s) • Includes a backdrop(s) • Requires input to trigger an action • Has an introduction scene that includes: ◦ The name of the game ◦ The objective of the game ◦ A sprite programmed using the coordinate system	• Time • Scratch

26 Guide students to view the **Star Clicker Game** to see a program with an introduction scene.

27 Have students work with their partner or group to create a plan for their program. The plan should include:

- Sprite(s)
- Backdrop(s)
- Actions of the sprite(s)
- Input(s) to trigger the actions
- Ideas for the introduction scene

28 Guide students to give their program a meaningful name. An example is Clicker Game Group 1.

29 Have students type the program name in the box and select **File**. Then select **Save Now**.

30 Allow students time to create their own clicker game.

Note: If your students needs more support on how to program their introduction scene, share Dot's program from the Star Clicker Game. Your students can modify the program for their game.



31 Guide students to test their programs and reflect on the questions:

- Does the game work as you intended?
- Does your game have all the required criteria?

Note: It is normal and expected that programs do not work exactly as intended at first. Encourage students to iterate and debug while programming.

32 Have students share their programs with the class. If possible, project the digital device screens with the programs so all students can view them. Guide students to:

- Discuss which blocks they chose to create their clicker game
- Identify the inputs and outputs of their program

33 Lead a discussion about the programs.

- What were the similarities in how everyone programmed their clicker games? What were the differences?
- How did you use Event blocks in your program?
- How did you use loops?
- How did you use variables?
- How did you use the coordinate system in your program?
- What bugs did you experience in your program?
- How did you debug your program?

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

Conclusion Questions Answer Key

1 Why is it important to understand the coordinate grid when programming?

Student responses should demonstrate an understanding of the coordinate grid. Example response:
It is important to understand the coordinate grid because Scratch uses a coordinate system to determine the location of sprites on the stage. Several Motion blocks use the x and y position to move sprites.

2 How did adding events, loops, and variables affect your program? Support your answer with evidence.

Student responses will vary.

3 If you could make a new game, what type of game would you create? What inputs and outputs would you include in your game?

Student responses will vary.

Problem

Game Time!

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) • Digital devices • Pencils or colored pencils for sketching	• Inkling • Scratch

RESOURCES

R

Decision Matrix

Summative Assessment

ESSENTIAL QUESTIONS

EQ

EQ1 How does technology impact our lives?

EQ2 In what ways do computing systems work together to accomplish tasks?

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 Apply computational thinking strategies to understand and solve problems.

LO4.1 Apply mathematical thinking to solve problems.

LO4.2 Understand that programmers use the coordinate system to move objects.

LO5 Collaborate effectively on a diverse and multidisciplinary team.

LO6 Communicate effectively for specific purposes using the appropriate platform, tool, format, or digital media.

LO7 Practice ethical behavior in all settings.

Preparation

Professional Development

Before you facilitate the problem, access the **Launchpad** to review the resource, Thinking Like an Engineer.

Problem

1. Become familiar with the procedures for facilitating this problem with your students. In this problem, students design a digital game that keeps children busy while they are waiting.
2. Watch these game tutorials in Scratch. Interact with the tutorials to create the games.
   - Animate an Adventure Game
   - Pong Game
   - Make a Chase Game

Note: The Make a Chase Game tutorial uses code blocks that do not work on tablets.



As an alternative, students could use this program to move a sprite by dragging it across the screen. Students will need to drop the sprite to score.



3. Create your own digital game based on the criteria and constraints in the Procedure. This helps you to facilitate the problem with students and understand challenges they may face.
   As your students work through this open-ended problem, remember that they may move beyond what you know about creating programs in Scratch. You do not have to be a coding expert, but you can support your students by asking good questions that move them forward in their work. If they get stuck, work with them to find tutorials that may provide help or to seek help from their peers.
4. During the Evaluate step of the design process, each group will pair with another group to exchange digital games to review and receive feedback. Plan how you will create and organize review groups.
5. Think of ways for students to share their games outside of the classroom that will keep children busy while they are waiting. Options include leaving digital devices in the school office, library, clinic, or drop off/pick up area.
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.

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.
KS3.2	Use data to highlight or propose cause-and-effect relationships, predict outcomes, or communicate an idea. [CSTA 1B-DA-07]
KS3.3	Compare and refine multiple algorithms for the same task and determine which is the most appropriate. [CSTA 1B-AP-08]
KS3.4	Create programs that use variables to store and modify data. [CSTA 1B-AP-09]
KS3.5	Create programs that include sequences, events, loops, and conditionals. [CSTA 1B-AP-10]
KS3.6	Decompose (break down) problems into smaller, manageable subproblems to facilitate the program development process. [CSTA 1B-AP-11]
KS3.7	Apply a Use-Modify-Create approach to develop programming skills. [CSTA 1B-AP-12]
KS3.8	Use an iterative process to plan the development of a program by including others' perspectives and considering user preferences. [CSTA 1B-AP-13]
KS3.9	Test and debug (identify and fix) a program or algorithm to ensure it runs as intended. [CSTA 1B-AP-15]
KS3.10	Brainstorm ways to improve the accessibility and usability of technology products for the diverse needs and wants of users. [CSTA 1B-IC-19]
KS4.1.1	Make sense of problems and persevere in solving them. [CCSS.MATH.PRACTICE.MP1]
KS4.1.2	Reason abstractly and quantitatively. [CCSS.MATH.PRACTICE.MP2]
KS4.1.4	Use appropriate tools strategically. [CCSS.MATH.PRACTICE.MP5]
KS4.1.5	Look for and express regularity in repeated reasoning. [CCSS.MATH.PRACTICE.MP8]
KS4.2.1	Develop a basic understanding of the coordinate system.
KS4.2.2	Demonstrate the correct use of the coordinate system when moving objects in a block-based coding platform.
KS5.1	Generate ideas as a team.
KS5.2	Value the contributions of each team member.
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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.
KS7.1	Engage in and maintain positive interactions and relationships with other children and adults.
KS7.2	Engage in positive, safe, and legal behavior while using the internet and technology.

Time: 180 Minutes

Introduction

In this problem, students participate in a class hackathon and follow the *design process* to design a game for children to play on a digital device. Students document their progress in their PLTW Launch Logs, share their games with others to receive peer feedback, and evaluate the success of their programs.

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: *The Waiting Game* with students. Lead a discussion to review the story.

   - What is the problem Angelina, Mylo, and Suzi face?
   - How does Ms. Morales suggest they solve the problem?
   - Have you participated in a hackathon before? If so, describe the project you worked on.

2. Direct students to access the problem in the student course and have them read the Introduction.
3. Review the Use-Modify-Create Framework with students. Share with students that they will follow this framework as they work through the design process to solve the problem.
4. Lead a discussion about the framework.

   - How will this approach help you solve the problem?
   - What do you think you can use that will help you create a digital game?

5. 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.
6. Present the Design Process video as an introduction to engineers and the design process.



Design Process video

7. 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.

8. 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 PLTW 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.

9. Guide students to follow the design process to create a game for children to play on a digital device.

10. 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 we design a digital game that keeps children busy while they are waiting?"
    - 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 digital game: • Includes a sprite(s) • Includes a backdrop(s) • Requires input to trigger output • Is designed for the intended audience • Has an introduction scene that includes: ▪ The name of the game ▪ The objective of the game ▪ How to play the game ▪ How to end and/or win the game ▪ The ages the game is designed for ▪ A sprite programmed using the coordinate system	• Time • Scratch

    - 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?
- What does it mean for a game to be designed for the intended audience?
- What do you need to consider when designing a game for an intended audience?
- 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?

Note: Be sure students understand what an intended audience means. Since students can create a game for different ages, it is important for them to keep their audience in mind while they design the game. For example, if students decide to create a game for children ages 4 or 5, they need to design a simple game. If students decide to create a game for older students, the game can be more complex.

- Guide students to record their responses in the Ask step of their PLTW Launch Logs.
- Have students complete the self-reflection at the end of the Ask section in their PLTW 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.

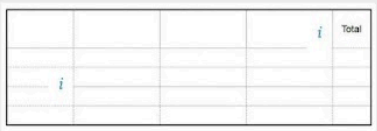
11 The second step in the design process is **Explore**.

- Review the Use-Modify-Create Framework graphic with students. Explain to students that they will watch three more tutorials to learn about different types of games. They will apply what they learn in these tutorials along with what they learned in Activity 3 and the project to create their digital game.
- Guide students to work with their group to interact with the Make a Chase Game, Pong Game, and Animate an Adventure Game tutorials.
- As students interact with the tutorials, remind them to:
  - View the videos first. Then use the slides as they drag out code blocks and test the code.
  - Test their code as they build the 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.
  - Modify the programs they create in the tutorials. This helps them learn more about programming.
- Guide students to brainstorm several ideas that may solve the problem. Students can use the skills and knowledge they gained from the activities and project in this module, as well as what they learned in the game tutorials.
- In the corresponding section of their PLTW Launch Logs, direct students to record ideas and use labeled sketches to detail their digital game.
- Guide students to share their initial ideas with their group. Encourage them to add any new ideas by writing or sketching in their PLTW 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.

12 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.

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



  - 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.
- Guide students to use the chosen solution to create their digital game.
- Remind students to:
  - Revisit the criteria so their design contains all elements.
  - Test their program often.
  - Talk with their classmates if they need help with their program.
  - Practice good pair programming strategies.

- To facilitate the creation of the digital games, 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 PLTW Launch Logs. Assess student understanding and record comments as needed.

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

- Direct students to swap digital games with another group. Allow time for each group to try each other's digital game.
- Guide groups to give each other feedback on the strengths and weaknesses of their digital games. Have them consider:
  - Did the digital game solve the design problem?
  - Were the instructions thorough enough for us to play the digital game?
  - What was our favorite part of the game?
  - What can be done to improve the digital game?
- Guide students to reflect on the strengths and weaknesses of their game. Have them consider:
  - Does the digital game address all criteria?
  - Will the game keep children busy while they are waiting?
  - What can we do to improve the digital game?
- Allow time for students to revise their digital games and make them better.
- Have students complete the self-reflection at the end of the Evaluate section in their PLTW Launch Logs. Assess student understanding and record comments as needed.

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

- Have students share their digital games with the class. If possible, project the digital device screens with the programs so all students can view them. Guide students to discuss:
  - The intended audience of their game
  - The input and output of their program
  - How they used the coordinate system
  - The code blocks they chose to create their digital game
- After students view all of the digital games, lead a discussion about their features, strengths, and weaknesses.



  - What did you like the best about another group's game? Why did you like that?
  - Was there anything from another group's game that you would like to incorporate into yours? How would you use that in your program?
  - If you could improve anything about your program, what would you improve? Why would you improve that?
  - How does working together in a hackathon help us solve problems?

- Guide students to complete the Explain section of their PLTW Launch Logs. Have students provide suggestions for improvement for their digital game and support those with evidence.
- Have students complete the self-reflection at the end of the Explain section in their PLTW 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 Input/Output: Computer Systems 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 While designing your digital game, you had to make sure you were meeting the criteria. Why it is helpful to know the requirements of a program before you start to work on it?

Student responses will vary. Encourage students to use the vocabulary from the module as they explain their thinking.

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

Student responses will vary.

3 If you could design a new digital game, what would you design? What would be the input and output of the game?

Student responses will vary.

Introduction to the Module

Input/Output: Human Brain

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: Input/Output: Human Brain Teacher Guide.

PREFACE

Time: 10 instructional hours

In this module students are introduced to the analogy of the brain as a computer. They explore the various inputs and outputs of the human body. Students discover how signals passing from cell to cell allow us to receive stimuli from the outside world, get this information to the brain for processing, and then send out a signal to generate a response. Students investigate how we take in information through the senses and where the information is processed in the brain. Additionally, students explore how the brain and body react to stimuli. Students work as part of a team to design, plan, and create a video or podcast to raise awareness about concussions and educate children as to how concussions can either be identified early or prevented all together. Students follow a design process, a step by step way to solve problems, to help develop their video or podcast.

TRANSFER

T

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

1. Identify how damage to any part of the nervous system might impact function.
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. The nervous system is composed of many unique structures, each with a specific function.
10. The nervous system receives stimuli from the outside world, interprets this information, and generates an appropriate response.
11. Brain processing determines how we store memories and how quickly and appropriately the body responds to internal and external stimuli.
12. Damage to the nervous system can lead to disease or dysfunction.

169

KNOWLEDGE

K

It is expected that students will ...

- Describe how each region within the brain helps control and regulate specific functions in the body.
- Describe how different sense receptors are specialized for particular kinds of information.
- Describe how the organs responsible for each sense communicate with the brain.
- Recognize that the nervous system relies on specialized cells called neurons to pass signals to and from the brain and spinal cord.
- Recognize that many brain injuries can be prevented.

SKILLS

S

It is expected that students will ...

- Identify major regions of the human brain.
- Outline what happens in the human body from an initial stimulus to a response.
- Perform an investigation in order to draw conclusions.
- Maintain a notebook to document work.
- Share findings and conclusions with others.
- Follow a step by step method to solve a problem.

ESSENTIAL QUESTIONS

EQ

1. How does your body sense input from the outside world and make an appropriate response?
2. How can medical professionals use patient symptoms to diagnose brain injuries?
3. How does information we see in the media influence our decisions about healthy behavior?

RESOURCES

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

Preparation

Note: In preparation for teaching this module, it is strongly recommended that the teacher read the Input/Output: Human Brain 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 Input/Output: Human Brain 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 **Input/Output: Human Brain Module-specific PD Resources** to review:
  - Input/Output: Human Brain APB Overview
  - Scientific Inquiry Process video
  - Building Your Understanding: Body Systems
  - 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 **Fourth Grade Curriculum Revisions**.

Activity 1

The Body's Computer

Teacher Resources

View Student Course

EQUIPMENT

Based on 30 students. Please note that additional resources, such as documents and presentations, may need to be accessed from the curriculum course.

Included in Equipment Kit	Not Included in Equipment Kit	Device Applications
• Body Outline (1 per group) • Non-hardening modeling clay (6 colors per group) • Resealable plastic bags • Toothpicks • White adhesive labels	• Launch Logs (1 per student) • Digital devices • Clear tape • Colored pencils or markers • Nervous System Resource Sheet (1 print per student) • Hot glue and hot glue gun (optional)	• Inkling

RESOURCES

- Launch Log Grades 3-5
- Introduction to Input/Output: Human Brain
- Nervous System Resource Sheet
- Body Outline
- Nervous System Information

KNOWLEDGE AND SKILLS

KS

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

- Describe how each region within the brain helps control and regulate specific functions in the body.
- Recognize that the nervous system relies on specialized cells called neurons to pass signals to and from the brain and spinal cord.
- Identify major regions of the human brain.

ESSENTIAL QUESTIONS

EQ

1. How does your body sense input from the outside world and make an appropriate response?
2. How can medical professionals use patient symptoms to diagnose brain injuries?
3. How does information we see in the media influence our decisions about healthy behavior?

Activity 1: The Body's Computer

80 minutes

- Prior to running this module, the teacher may want to review the **Nervous System Information**. The information on this sheet is meant to provide a deeper understanding of the anatomy and physiology of the nervous system for teachers preparing to teach the module. The content presented goes above and beyond the content presented to students in the module. Because information about the nervous system can be very complex for students, the content in the module has been distilled to make sure that the information is presented in an age-appropriate manner for students. In order to do this, only the essential information is included, and many concepts have been simplified.
- 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.
- Prior to running this activity with students, the teacher prints a **Nervous System Resource Sheet** for each student.
- The teacher introduces students to the curriculum course and assists students with the login process. For the remainder of the module, the students will access the assignments in the curriculum course and record their work in their individual Launch Logs.
- Prior to beginning this module, the teacher should ask the students to remember the following five words – apple, table, fire, baby, and clock. The teacher can chose to just say the words or temporarily write them on the board. The teacher should not tell students why they are to remember these five words; just tell students that they will return to this later in the module and see how many of the words they can remember.
- As part of the activity, the teacher reads the Input/Output: Human Brain 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 posed in the fictional story.
- The teacher introduces Activity 1: The Body's Computer. In this activity students are introduced to the structure and function of the nervous system and learn about the brain and spinal cord. They will build a model brain out of clay and identify what each region of the brain does.
- 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.
- The teacher directs students to Activity 1: The Body's Computer.
- The teacher distributes one **Body Outline** to each group of students. Students will use this body outline throughout the Input/Output: Human Brain module. Note that the Body Outlines come in the kit, but an optional smaller version is available for you to print. If you choose to use the smaller outline, remind students that they have to use small print to fit all of the necessary information.
- The teacher distributes a Nervous System Resource Sheet to each student. Students will read informational text about the nervous system, the brain, and the spinal cord 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 in the below row. 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.

Nervous System

1. What does your nervous system do?

> Teacher Only
>
> The nervous system coordinates everything you do.

2. The body is made up of small structures called _____.

> Teacher Only
>
> Cells

3. What is the neuron's job?

> Teacher Only
>
> Carry messages throughout the body

The Central Nervous System and the Peripheral Nervous System

1. The nervous system is broken down into what two parts?

> Teacher Only
>
> *The central nervous system and the peripheral nervous system*

2. What two structures make up the central nervous system?

Teacher Only

The brain and spinal cord

3. What are nerves?

Teacher Only

Bundles of neurons

4. The nerves of the peripheral nervous system branch out to _____.

Teacher Only

The rest of the body

The Brain

1. The brain can be thought of as _____.

Teacher Only

The control center or central computer for your nervous system

2. What does your brain control?

Teacher Only

Your entire *body.*

3. What are the different parts of the brain?

Teacher Only

The cerebellum, the brain stem, the frontal lobe, the parietal lobe, the occipital lobe, and the temporal lobe

The Spinal Cord

1. The spinal cord is actually a bundle of _____.

Teacher Only

Nerves

2. What do the bones of the spinal column do for the spinal cord?

Teacher Only

Protect it

3. The spinal cord can be thought of as a _____.

Teacher Only

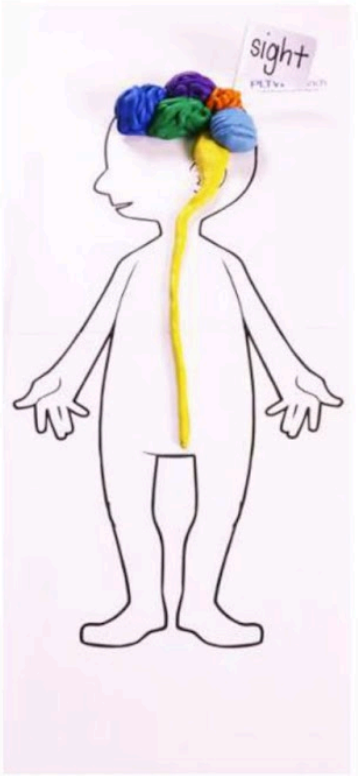
Highway for messages

4. The messages that travel are actually tiny _____.

Teacher Only

Electrical signals

- The teacher guides students through the remainder of the activity. The teacher models building the frontal lobe of the cerebrum for students. Students will watch and follow along as they build a frontal lobe for their own clay brain models.
  - Choose which color you want to represent your frontal lobe. Students may choose from any of the colors available to them.
  - Use the chosen clay to make a ball that is a little bigger than a golf ball.
  - Roll the ball into a long tube.
  - Carefully fold this long tube back into a loose ball. The ball should now have folds and grooves similar to the brain. This is your model frontal lobe.
  - Place your frontal lobe in the front top center of your skull. Use the picture of the brain to help you with this placement.
- Students will notice that the surface of the brain does not look smooth. The cerebrum (with its four lobes) is covered by folds and grooves. The teacher can guide students to make a loose fist with their hand and look at the top of their fingers. The fingers are like the folds, and the grooves between fingers are like the grooves, creating a shape similar to the surface of the brain.
- The teacher can note that the cerebrum actually has two halves, one on either side of the head, but students do not need to show this on their model since they are only creating a model of one half of the brain.
- Students complete the remainder of the activity and build the entire central nervous system (brain and spinal cord) on their body outlines. They will return to their body outlines in the next activity and in the project. The teacher should note that it is okay to place the clay over the ear on the body outline.



- Depending on how the teacher chooses to store the body outlines, the teacher may choose to have students glue the clay to the outlines using hot glue. If the teacher chooses to store the body outlines stacked one on top of the other, use upside down plastic cups as spacers between each model.
- The Conclusion Questions may be answered individually in the Launch Log or may be discussed in large or small groups.
- The teacher guides the students on the logout procedure for the curriculum course.

Activity 2

Senses Exploration

Teacher Resources

View Student Course

EQUIPMENT

Based on 30 students. Please note that additional resources, such as documents and presentations, may need to be accessed from the curriculum course.

Included in Equipment Kit	Not Included in Equipment Kit	Device Applications
• Scent Kit (1 per class) • Brown paper bags (1 per group) • Sight Tests (2 per class) • Body Outline (with CNS attached)	• Launch Logs • Digital devices • Colored pencils or markers • Ruler • Miscellaneous sensory items • Sight Station Tests • Taste Station Word Bank • Senses Exploration Resource Sheet (1 print per student) • Hearing Station presentation • Brain model from Activity 1	• Inkling • Stopwatch

RESOURCES

Senses Exploration Resource Sheet

Senses Exploration Answer Key

KNOWLEDGE AND SKILLS

KS

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

- Describe how each region within the brain helps control and regulate specific functions in the body.
- Describe how different sense receptors are specialized for particular kinds of information.
- Describe how the organs responsible for each sense communicate with the brain.

ESSENTIAL QUESTIONS

EQ

1. How does your body sense input from the outside world and make an appropriate response?
2. How can medical professionals use patient symptoms to diagnose brain injuries?
3. How does information we see in the media influence our decisions about healthy behavior?

Activity 2: Senses Exploration

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 reviews Activity 2: Senses Exploration and decides how to facilitate the station-based work. Most of the stations can take place at student desks, so students do not need to move around the room for the entire activity. Students will record information about each sense and about the associated sensory experience on the Senses Exploration Resource Sheet.
- Prior to running the activity, the teacher sets up the following station activities:

Smell

- Use the Scent Kit to prepare 4-5 different scent bags per station. Place each scent into a brown lunch bag. Cut a few holes in the bag and staple the bag closed. Label the bag as Scent #1. Repeat the procedure to prepare one bag per mystery smell. Label the bags accordingly.

Hearing

- No advance preparation is required. The teacher makes sure students have access to the Hearing Station presentation.

Touch

- Prepare 4-5 different touch bags per station. Choose items that will be interesting for the students to identify by touch. Example items include candy in a wrapper, jacks, toy cars or trucks, clay. Place each item in a brown lunch bag. Fold over the top of the bag and label the bags with numbers.

Sight

- No advance preparation is required. The teacher makes sure to place the three sight test pages face down at the station or has the students access the tests in the curriculum course.

Taste

- No advanced preparation is required. The teacher may want to have the Taste Station Word Bank sheet printed out at the station. Alternatively, the teacher may provide different foods for students to taste. It is up to the teacher to check for student allergies and provide safe foods for the students to eat.

- The teacher opens a discussion about how our brains take in information from the outside world.
- The teacher asks students to name the five senses and writes the words Smell, Sight, Hearing, Touch, and Taste on the board. The teacher introduces Activity 2: Senses Exploration and informs students that they will investigate how the organs associated with the senses communicate with the brain. Students access the activity using the app on a device. The teacher distributes the Senses Exploration Resource Sheet.
- The teacher presents the Nemours KidsHealth – *How the Body Works: Movies* on the senses to the entire class. The videos are available from: **http://kidshealth.org/en/kids/center/htbw-main-page.html?WT.ac=k-nav**. *If the hyperlink is not working, you can search the KidsHealth website, search for *How the Body Works*, and locate *How the Body Works: Movies*.
  - Movie: Tongue
  - Movie: Eyes
  - Movie: Skin
  - Movie: Nose
  - Movie: Ears

  *Use of this link follows the KidsHealth Permissions Guidelines, which are available at **http://kidshealth.org/media/permissions/#mainContainer**.
- As students watch each movie, they should complete the following:
  - Label the drawing for each section using information from the video and the provided word bank.
  - Circle or highlight the part on each drawing that helps send signals about the sense to the brain.
  - Complete the sensory task associated with the station. Record any data or observations in the associated box on the Resource Sheet.
- The teacher notes that there is a Senses Resource Sheet Key. This key includes labeled sense drawings and indicates which part of the brain each sense is connected with. The structures that send signals about the sense to the brain have been circled on the key.
- Have students discuss all of the labeled diagrams before they move on to any of the sensory experiences.
- Alternatively, the teacher may have students view each of the sense movies on their individual devices.
- The teacher explains the sensory task for each station.

Smell

- Facilitation – Students will take each bag, one at a time, and try to identify the mystery smell. They should record their guess on the Resource Sheet (make sure to identify the bag with its corresponding number). Group members should not discuss their guesses until all members have tested each bag.

Hearing

- Facilitation – Students will access the **Hearing Station** Presentation on the device. One student per group will play each sound, and the other students in the group will guess what sounds they are hearing. Group members should not discuss their guesses until all members have written down their responses. The student who played the sounds should write down any memories that the different sounds might have triggered.

- Alternatively, the teacher may choose to complete this station as a whole class and play the sounds for the students so that each student has the opportunity to guess the sounds.

Touch

- Facilitation – Without looking, students will have 10 seconds to touch the item in each bag. Students should guess the contents in each bag and record guesses on the Resource Sheet (make sure to identify the bag with its corresponding number). Group members should not discuss their guesses until all members have tested each bag.

Sight

- At this station students will explore a phenomenon known as the "Stroop Effect." Named after J. Ridley Stroop, who discovered this interesting trick of the mind, Stroop testing asks the person to name color used in various words. This gets tricky as the word BLUE may be printed in red color. The reader should say red to identify the color, but the words themselves have a strong influence over what the reader might say.
- The teacher informs students that this test is being used to explore how our brain processes what we see. Students will complete three tests to explore this phenomenon.
  - Test 1 – Blocks of colors are shown.
  - Test 2 – The word for each color is shown in the correct color.
  - Test 3 – The word for colors are shown; however, the color font does not match the word.
- Students will most likely notice that it takes them more time to complete Test 3 than it did to complete Test 1 and Test 2. They will probably also note an increased rate of errors. The brain is trying to make sense of two conflicting pieces of information: seeing and interpreting.
- Facilitation – Each student should complete all three tasks in a row. Another student in the group should identify the time it takes the subject to identify each color as they work their way across all three rows of the sheet. The timer will use the device stopwatch app and should document any incorrect responses in each test. Data should be recorded in the table on the Resource Sheet.

Taste

- Students will take turns describing specific foods to one another (without using the food name). These descriptions should highlight taste. The other students in the group try to guess the food being described. The students can access the Taste Station Food Bank to help them describe their foods.
- Alternatively, the teacher may bring in food items and have students taste each item and guess what they are tasting.

- The teacher circulates around the room as the students work through the senses activities.
- The teacher holds a discussion about student's observations from each station. The teacher reminds students how it is that each sensory organ communicates information to the brain. In the next activity, students will investigate memory and how we store information.
- The teacher instructs students to view the body outlines and brain models they created in Activity 1.
- Students should look at the tape flags they have placed on the model brain and determine which part of the brain is primarily responsible for each sense. Students should add this information to their Resource Sheet and highlight this information on the tape flags.
- The Conclusion Questions may be answered individually in the Launch Log or may be discussed in large or small groups.
- The teacher guides the students on the logout procedure for the curriculum course.

Activity 3

The Brain in Action

Teacher Resources

View Student Course

EQUIPMENT

Based on 30 students. Please note that additional resources, such as documents and presentations, may need to be accessed from the curriculum course.

Included in Equipment Kit	Not Included in Equipment Kit	Device Applications
• Memory game cards	• Launch Logs • Digital devices • Colored pencils or markers • Classroom items (10-15 per station)	• Inkling • Stopwatch • One of the following: ◦ Reaction Test Pro by Freedom Apps (iPad®) ◦ Reaction Time by KovetsTech (Android or Chrome OS)

KNOWLEDGE AND SKILLS

KS

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

- 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 does your body sense input from the outside world and make an appropriate response?
2. How can medical professionals use patient symptoms to diagnose brain injuries?
3. How does information we see in the media influence our decisions about healthy behavior?

Activity 3: The Brain in Action

120 minutes

- This activity may be taught over a series of class periods as determined by the teacher and is estimated to take 120 minutes to complete.
- Prior to running this activity, the teacher sets up the following memory station activities:
  - Memory Game Station
    - Depending on the number of stations you want students to rotate through, place memory cards face down at each station (make sure that the cards placed at each station have a match). There are two game card sets available in the kit, each containing 48 cards.
  - Remember That Object! Station
    - Collect a set of 10 – 15 everyday classroom objects, such as pencils, pens, erasers, books, etc. on a desk or a tray. Cover the items so that students cannot see them until it is time to begin.
- The teacher introduces Activity 3: The Brain in Action and directs students to access the activity using the app on a device.
- In the last activity, students investigated how their body senses information such as sights, sounds, and tastes from the world around them. In this activity they will investigate how the brain processes this information and how it stores the information as memories.
- Before students began this module, the teacher asked students to remember five words: apple, table, fire, baby, and clock. Students will determine how well they were able to recall the five words. Whether or not they were able to recall these words depends on whether they transferred this information into their long-term memory.
- Students access the procedure for Activity 3. The teacher will guide students through the stations.
  - Memory Game Station
    - Students will play with a partner and place the cards face down in random order. They will take turns flipping the cards over and pairing together matching cards, just like the traditional memory card game. Whichever student collects the most correct pairs wins the game. Alternatively, teams of students can compete with other teams to see who completes the game first or play against the clock to see if they can complete the game within a set amount of time.
    - As a math extension, the teacher can consider running a memory game using multiplication tables. Students can create the cards and then play the game to match up the correct products with the multiplication equations.
  - Remember That Object! Station
    - Students will work with a partner. One partner will act as the timer, and the other partner will test his or her memory. The partner testing his or her memory will be given 30 seconds to view the items. The items will then be covered up, and the student will write down as many items as they can remember in their Launch Log.
- Students will test their reaction time using the Reaction Test Pro (iPad®) or Reaction Time (Android) application on their devices. They will test how long it takes to press the Stop button once the light on the screen changes color.
  - Students will record their results, with the decimal to the hundredths place. Depending on the level of the students, students do not need to round the number; instead, they can simply record the numbers to the hundredths place. For example, 0.398649 can be recorded as 0.39. It is up to the teacher if they want to take this further.
- In Part 2 of Activity 3, students will follow the Scientific Inquiry Process to design and complete an experiment that investigates the effect of a particular factor on reaction time (using the reaction test application) or memory. Factors they can test include: practicing, having distraction, or using their left versus right hand. The teacher guides the students through the five steps of the process as they complete their investigation: Ask, Predict, Investigate, Observe, and Explain.
  - The teacher may want to model an example investigation for students before they begin work on their own.
- The Conclusion Questions may be answered individually in the Launch Log or may be discussed in large or small groups.
- The teacher guides the students on the logout procedure for the curriculum course.

Project

Information Processing

Teacher Resources

View Student Course

EQUIPMENT

Based on 30 students. Please note that additional resources, such as documents and presentations, may need to be accessed from the curriculum course.

Included in Equipment Kit	Not Included in Equipment Kit	Device Applications
• White poster board (1 per group) • Red yarn • Blue yarn • Body outline (with CNS attached)	• Launch Logs • Digital devices • Colored pencils or markers • Peripheral Nervous System Resource Sheet (print 1 per student) • Tape	• Inkling • Chrome

RESOURCE

Peripheral Nervous System Resource Sheet

KNOWLEDGE AND SKILLS

KS

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

- Describe how each region within the brain helps control and regulate specific functions in the body.
- Describe how different sense receptors are specialized for particular kinds of information.
- Describe how the organs responsible for each sense communicate with the brain.
- Recognize that the nervous system relies on specialized cells called neurons to pass signals to and from the brain and spinal cord.
- Outline what happens in the human body from an initial stimulus to a response.

ESSENTIAL QUESTIONS

EQ

1. How does your body sense input from the outside world and make an appropriate response?
2. How can medical professionals use patient symptoms to diagnose brain injuries?
3. How does information we see in the media influence our decisions about healthy behavior?

Project: Information Processing

120 minutes

- This project 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 prints **Peripheral Nervous System Resource Sheet** for each student.
- The teacher introduces the project and directs students to access the project using the app on a device.
- Students watch the **Input and Output in the Human Body** presentation and write an example of an input and an output in the human body in their Launch Logs. Review the presentation on a student device to make sure it works.

> **Note for iPad Users**: This presentation works best in the Chrome browser. If your students use iPads with Safari as the default browser, show them how to open the presentation in the Chrome app. To learn how, view the How to Open an Asset in Chrome on an iPad presentation.



How to Open an Asset in Chrome on an iPad presentation

- Students practice identifying inputs and outputs from the following scenarios.
  - A person puts their hand on a hot surface. The person then moves their hand off the hot surface to avoid getting burned.
    - The input is the hand sensing the hot surface. The output is the hand moving off the surface.
  - A person is walking and is about to cross the street. The person sees a car coming and stops walking to avoid being hit.
    - The input is seeing the car coming. The output is the muscles of the legs stopping moving.
  - A person hears a fire alarm and therefore walks out of the building.
    - The input is hearing the fire alarm. The output is the muscles of the legs moving the body out of the building.
- The teacher distributes a Peripheral Nervous System Resource Sheet to each student. Students will read informational text about the peripheral nervous system and neurons 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 in the below row. 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.

Peripheral Nervous System:

1. The peripheral nervous system is made up of _____.

> Teacher Only
>
> Nerves

2. What are nerves?

> Teacher Only
>
> Bundles of neurons

3. Neurons send signals to and from the brain as _____.

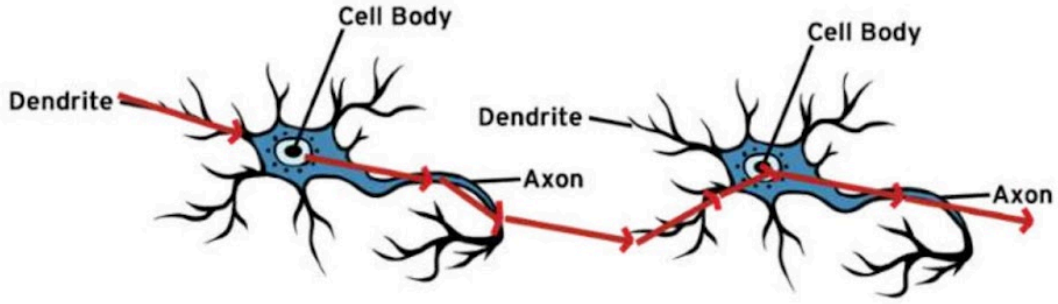
> Teacher Only
>
> Electrical impulses

4. How do signals move from neuron to neuron?

> Teacher Only
>
> They jump from neuron to neuron

The Neuron

1. Use arrows to draw the movement of information through the neurons below.



Sensory and Motor Neurons

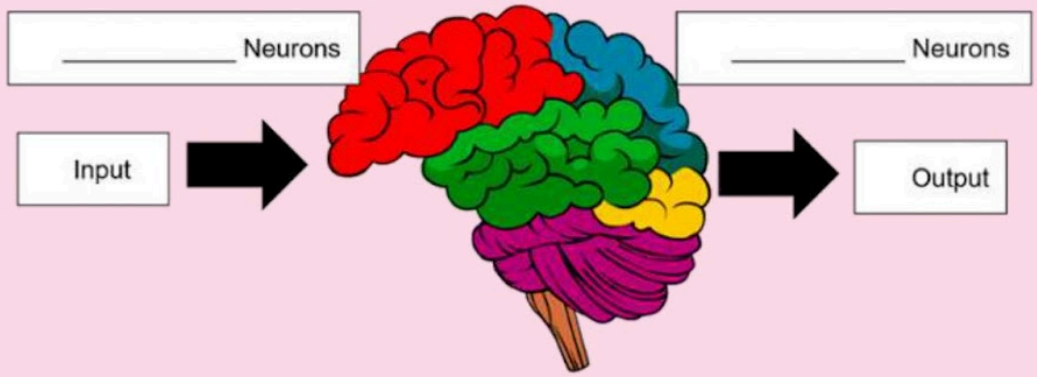
2. Where is information processed?

Teacher Only

The brain

3. Write in which type of neurons are responsible for carrying the input and output to and from the brain in the diagram below.

Teacher Only



Cranial and Spinal Nerves

1. What do cranial nerves connect to?

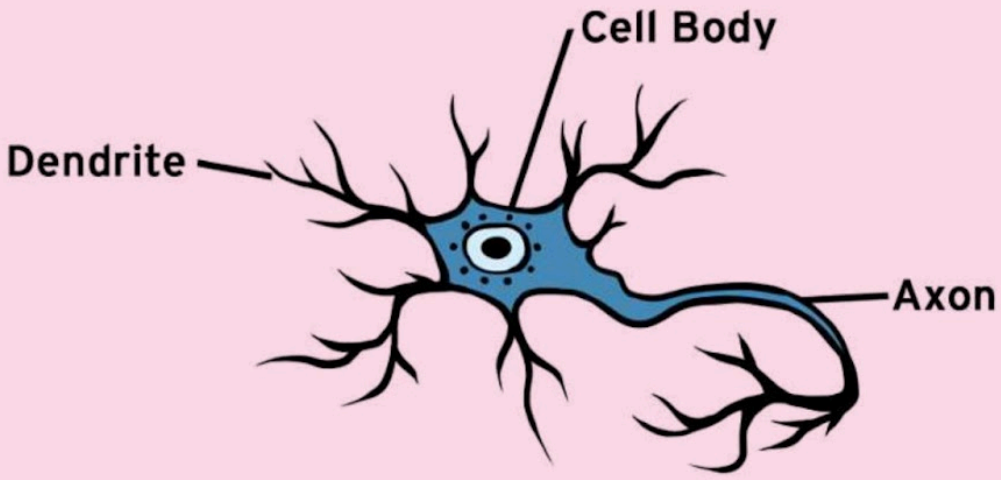
Teacher Only

Directly to the brain (and brain stem)

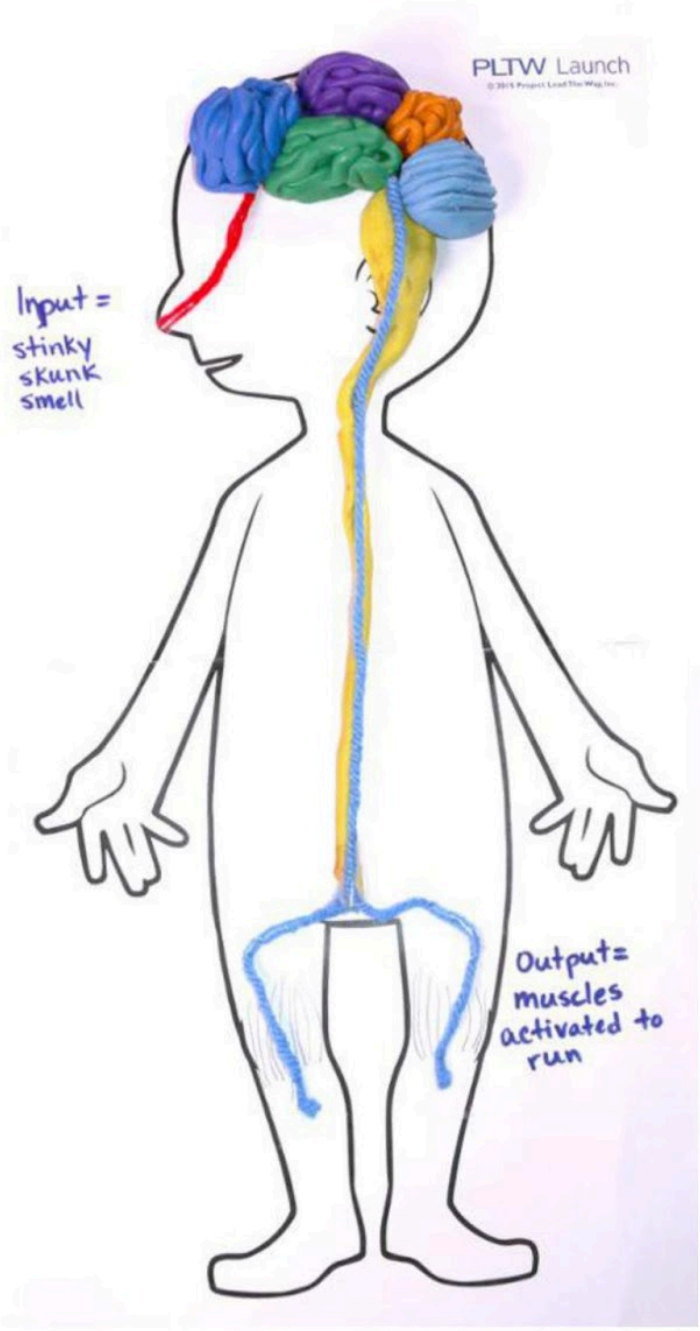
2. What do spinal nerves connect to?

Teacher Only

Connect with the spinal cord



- The teacher should review the idea of neurons passing along information by completing a kinesthetic activity with the class. Students should stand in a line across the classroom. Instruct them to use one hand as a dendrite and the other as an axon. Begin a signal with the first "neuron" by squeezing his or her hand (a set number of times). The student should then pass on this code from his/her axon to the dendrite of the next student. This continues until the information makes it to the final student who completes the action and jumps (kicks, claps) the number of times indicated by the code, indicating that the message has been received. The teacher will guide a discussion about what the input and output were for this activity (the input was the number of squeezes and the output was the action of jumping, kicking, or clapping the number of times as indicated by the code). If students don't want to hold hands, the teacher can modify the activity to have students play a game of telephone and pass the message.
- The teacher instructs students to take out their body outline that contains the components of the central nervous system and the sensory paragraph they wrote at the end of Activity 2.
- The teacher helps students brainstorm three sensory experiences they can use to model how sensory neurons sense changes inside and outside the body and send this information to the central nervous system. Once the brain processes this information, a signal is sent out via motor neurons to bring about a reaction or change. For example, a student may note smelling a skunk in a forest. They may react by running away to avoid being sprayed.
- The teacher provides students with red and blue yarn, tape, and markers and circulates around the room as students attempt to model processing in the nervous system.
- For each of the three experiences they identify, students will use yarn to trace the path of information to and from the central nervous system on the body outline. Alternatively, the teacher may choose to have students draw the path with colored pencils instead of using yarn.
  - Students will determine the input and output for each of their three situations. They will add text boxes on the body outline that describe the input and the output for each. They will use a different color marker for each input/output pair. In the case of the skunk, they may note that
    - Input = stinky skunk smell
    - Output = muscles activated to run
  - Students will use red yarn to show how the input moves through the body to the brain. The path should start where the body senses the information and end at the area of the brain where this information is processed.
    - Student will draw organs or other body parts on the outline as needed to show where the input information is entering the body.
    - Students should note that for most information this means going through the spinal cord. However, signals that come from above the neck, as is the case for sights, smells, and sounds, follow cranial nerves directly to the brain.
    - In the skunk example, the sensory neurons in your nose send signals directly to the olfactory bulb in your brain (located at the bottom of the frontal lobe). You would draw a nose on your body outline and use red yarn to string from the nose to the bottom of the frontal lobe.
    - Students will attach the string to the body outline with tape.
  - Students will use blue yarn to show how the output moves from the brain through the body to generate a response. The path should start at the brain where the input was processed and end where the body's response occurs.
    - Students will draw organs or other body parts on the outline as needed to show where the output is occurring in the body.
    - In the skunk example, your brain processes this information and may decide you should run away. Motor neurons send messages from the brain, through the spinal cord, to muscles of the leg to cause this reaction. You would draw muscles on the leg and use blue yarn to string from the brain, down the spinal cord, to the leg muscles.
    - Students will attach the string to your body outline with tape.



- The Conclusion Questions may be answered individually in the Launch Log or may be discussed in large or small groups.
- The teacher guides the students on the logout procedure for the curriculum course.

Problem

Brain Injury Prevention

Teacher Resources

View Student Course

EQUIPMENT

Based on 30 students. Please note that additional resources, such as documents and presentations, may need to be accessed from the curriculum course.

Not Included in Equipment Kit	Device Applications
• Launch Logs • Digital devices • Colored pencils or markers • Storyboard Resource Sheet (1 per group)	• Inkling • iMovie (iPad®) • ShowMe Interactive Whiteboard • Camera

RESOURCES

Storyboard Resource Sheet

Summative Assessment

KNOWLEDGE AND SKILLS

KS

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

- Describe how each region within the brain helps control and regulate specific functions in the body.
- Recognize that many brain injuries can be prevented.
- Maintain a notebook to document work.
- Share findings and conclusions with others.
- Follow a step by step method to solve a problem.

ESSENTIAL QUESTIONS

EQ

1. How does your body sense input from the outside world and make an appropriate response?
2. How can medical professionals use patient symptoms to diagnose brain injuries?
3. How does information we see in the media influence our decisions about healthy behavior?

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: Brain Injury Prevention

200 minutes

- The teacher introduces Problem: Brain Injury Prevention and directs students to access the problem using the app on a device.
- In this problem students will work as part of a team to design, plan, and create a video or podcast to raise awareness about concussions and educate their peers as to how concussions can either be identified early or prevented all together. They will follow a design process, a step by step way to solve problems, to help them develop their video or podcast.
- The teacher either reads the Input/Output: Human Brain Introduction story or reminds students of the story that sets the stage for the design problem.
- Students access the procedure and work through the design process to create their video or podcasts.
  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 consider the problem. Remind students that the intent of the video or podcast is to bring awareness to other kids and help educate them so they can identify concussions early or prevent concussions from occurring. The video or podcast needs to be informative and engaging to its audience. Students should pick a sport or activity that they are interested in and use this to create the story they will portray in their video or podcast.
b. The students review the criteria and constraints of the problem by reading through step 3 in the procedure.
c. The teacher has a few options for facilitation alternatives with this problem.

- The teacher may choose to have the final product be a class project, assigning students roles such as actors, researchers, writers, etc.
- The teacher may choose to have students perform skits rather than create videos.

d. The students respond to the following questions in their Launch Logs.

- What is the need or want that we are trying to fulfill?
- What will make the design solution (the video or podcast) successful?

e. 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 research and brainstorm ideas.
b. Students record all research and ideas in the Explore section of their Launch Log.
c. 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 create a plan for their video or podcast and document it as a script. If they are creating a video, the teacher should help guide them in the creation of a storyboard where they identify what will be done at each part of the video. The teacher should distribute a **Storyboard Resource Sheet** for students to use to document their storyboards.
b. The teacher will approve student scripts before they begin recording their videos or podcasts.
c. Students can use the iMovie or ShowMe Interactive Whiteboard app to create their videos or podcasts.
d. 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 create a peer evaluation test for their classmates to use to evaluate their videos or podcasts.
b. The teacher should guide students to create rating scales and questions that determine how well the video or podcast met all of the criteria. Students will use this information to determine how they can improve their videos or podcasts.
c. Students record the results of their peer evaluation tests in their Launch Log.
d. The teacher guides the students as they complete the self-assessment at the end of the Evaluation section in their Launch Log.

Explain

a. The teacher leads the students through this step of the design process. Students will summarize and share what they learned from this problem in their Launch Log.
b. Students will provide suggestions for improvement based on evidence from their peer evaluation tests.
c. The teacher guides the students as they complete the self-assessment at the end of the Explain section in their Launch Log.

- The teacher should consider sharing student work with other classes and around the school. The teacher can also consider creating a video contest for students to see which group can create the best video. Note that every year the Society for Neuroscience hosts a "Brain Awareness Video Contest" to

produce an educational video about the brain that can appear on the www.brainfacts.org website. Although the contest is geared for older students, the teacher can use this contest to help engage students.

- The Conclusion Questions may be answered individually in the Launch Log or may be discussed in large or small groups.
- The teacher guides the students on the logout procedure for the curriculum course.
- Direct students to complete the Input/Output: Human Brain Check for Understanding. You can access a printable version of this assessment in the Resources section of the **Summative Assessment** page.

Introduction to the Module

Organisms: Structure and Function

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: Organisms: Structure and Function Teacher Guide.

PREFACE

Time: 10 instructional hours

In this module, students learn the characteristics of living things and look for similarities among living organisms. Students examine a wide range of organisms, exploring their unique internal and external structures to understand how these structures support the organism's survival and combine with other structures to function as part of a larger system.

Students use their knowledge of the internal and external structures of organisms to design a fictitious plant that meets specific criteria. Students then apply the knowledge and skills gained through the activities and project as they work through the design process to research, design, and build a model prosthesis for an injured animal.

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



SPRINGFIELD PUBLIC SCHOOLS

ENGAGING STUDENTS • FOSTERING ACHIEVEMENT • CULTIVATING 21ST CENTURY GLOBAL SKILLS

Introduction Story

Animal Patients

Teacher Resources

View Student Course

RESOURCE

R

Introduction Story: Animal Patients

Time: 20 Minutes

Introduction

To set the stage for learning, guide students to read the Introduction Story: *Animal Patients*, 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: *Animal Patients*. 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 is 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

Exploring Living Things

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 Application
• Organism cards • Tape	• PLTW Launch Logs (one per student) • Digital devices • Sticky notes or scrap paper • Pencils or colored pencils for sketching • Chart paper • Markers	• Inkling

ESSENTIAL QUESTIONS

EQ

EQ1 How are organisms structured to support and sustain life?
EQ2 How do scientists and engineers understand the world around them?
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.
LO1.3 Construct and/or support an argument with evidence, data, and/or a model.
LO2.1 Analyze how the functions of internal and external structures of selected plants and animals support survival, growth, behavior and reproduction.
LO4 Collaborate effectively on a diverse and multidisciplinary team.
LO5 Communicate effectively for specific purposes using the appropriate platform, tool, format, or digital media.
LO6 Practice ethical behavior in all settings.

KNOWLEDGE AND SKILLS

KS

KS1.2.2 Make observations to draw conclusions of phenomena.
KS1.3.3 Describe or predict natural phenomena using evidence and/or data.
KS2.1.1 Identify characteristics of living things.
KS2.1.2 Identify what living things need to survive.
KS2.1.5 Describe how plants and/or animals survive, grow, behave and reproduce.
KS2.1.6 Compare and contrast structures of plants and animals and how their structures and functions are similar or different.
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.
KS6.1 Engage in and maintain positive interactions and relationships with other children and adults.

Introduction

What does it mean to be living? *Living things* all do the following: move, breathe, *reproduce*, *grow*, *excrete*, and *consume*. By comparing and contrasting a wide variety of living things and thinking creatively about how to group them based on their *characteristics*, students can start to uncover the characteristics living things have in common.

Preparation

Part 1. What Does It Mean to Be Living?

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.

characteristic	A limitation or a restriction. Constraints include limits on time, materials, and size.
consume	To take in (eat or drink) something as food.
evidence	Information that explains or supports a claim.
excrete	To remove or eliminate waste.
living thing	Anything that is alive or was once alive.
organism	A living thing that has an organized structure and can move (respond to stimuli), breathe, reproduce, grow, excrete, and consume.
reproduce	The process by which new living things are created from their parents.

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: *Animal Patients*** with students.
7. Prepare the opening questions by writing them on the board or on chart paper:
   - What does it mean to be a living thing?
   - What do all animals and plants need to survive?
8. Gather sticky notes or scrap paper and tape for students to write sentences and post underneath the opening questions.

Part 2. Habitats Around the World

1. Review the procedures for the Organism Cards activity.
2. Plan how you will group students for the Organism Cards activity.
3. Gather scratch paper or sticky notes for students to record the names of their Organism Card groupings.
4. Prepare the board or a piece of chart paper with "Round 1" and "Round 2" headings.

Possible Student Misconceptions

- **Something is alive because it moves, breathes, reproduces, grows, excretes, and consumes**. While all living things have these traits, they must also be made up of cells. For example, fire meets all of the requirements listed, but does not have cells, and so fire belongs in the nonliving category.
- **Insects are not animals**. An organism that is not a bacteria, plant, or fungus is an animal. All animals have a nervous system, have muscle cells to help them move, and have to eat to capture energy. While an insect does not look like a cat, fish, or a human, all of these animals share the same three traits.
- **We are not animals because we are people**. Since humans created the word "animal" and the category, we typically use it to describe creatures that are not us, but we fit the definition of animal: we have a nervous system, we have specialized cells like muscle cells and skin cells, and we have to eat to provide our bodies with energy.

Procedure

Time: 60 Minutes

Part 1. What Does It Mean to Be Living?

1. Direct students to access Activity 1 in the student course.
2. Lead a discussion for students to reflect on the Introduction Story: *Animal Patients*.

   - Which injured animal would you like to help?
   - What ideas come to mind when you think of designing a prototype to help one of these animals?

3. When students explore careers, they can see connections between what they are learning and real-world applications. Guide students to read about Derrick Campana, an animal orthotist and prosthetist.
4. Guide students to read the Introduction to Activity 1.
5. Distribute the Grades 3–5 Launch Log to each student. Students use PLTW Launch Logs to keep a record of their work as they progress through the module. They may take notes as they research, create sketches, and answer conclusion questions in this notebook.
6. Guide students to label a new page in their Launch Logs with the heading, "Exploring Living Things".
7. Lead a discussion of the questions found in the Introduction. This discussion provides an opportunity for formative assessment as students share their conceptions about living things. Throughout this activity, continue to ask questions to determine whether students' misconceptions are being addressed through the hands-on activities.

   - What does it mean to be living?
   - It may be easy to tell when a person or a dog is alive, but what about other things?
   - Is water alive? Is a tree alive? Is a rock alive?

8. Tell students that they are going to learn the characteristics of living things, also known as organisms. Direct students to access the flashcard examples as you introduce the vocabulary terms *living thing*, *characteristic*, and *organism*.
9. 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.

10. Model for students how to support a claim with evidence.

    Sample Claim: I think living things need food to survive.

    Sample Evidence: I think this because I am a living thing, and I need food to survive. Fish are also living things, and they need food to survive too.

11. Post and pose the following questions on the board or on chart paper.
    - What does it mean to be a living thing? Why do you think that?
    - What do all animals and plants need to survive? Why do you think that?
12. Direct students to make a claim in response to each question in their Launch Logs. Remind students to support each claim with evidence.
13. Direct students to share their claim statements with a partner using Think-Pair-Share. If students disagree with a claim, allow time for them to engage in arguments using evidence to support their claim. During the

    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.

share-out with the class, ask partners to summarize their partner's claims and how it was similar to or different from their own responses.

14. Allow partners to generate a revised claim to the first question based on the class share-out. Direct students to write their answer on a sticky note or piece of paper, and stick it under the question.

15. Lead a review of the revised claims that have been added to the chart. Tell students that they will investigate living things to find evidence to support or help them change their claims.

Part 2. A Wide World of Living Things

16. Guide students to work with the Organism Cards.
    - Divide the class into small groups.
    - Provide each group a set of the Organism Cards and sticky notes or scrap paper and tape.
    - Explain that each card has a picture of an organism on one side and its name and a few facts about the organism on the other side.

17. Model how to sort the Organism Cards. You may use a document viewer to project the images of the cards. Alternatively, have students gather around a table with the cards laid out.
    - Sort the cards into two groups: organisms that can move and organisms that cannot move.
    - Select a walking animal from the cards and model how to make a prediction about which group you will sort the card into.
    - Read the back of the card and look for evidence that supports your prediction or support your prediction based on the image of the organism's structures.

18. Direct students to go to their tables and sort their cards into the two groups: organisms that can move and organisms that cannot move.
    - After groups have finished, lead the class to share how the organisms were sorted and discuss differences among the groups.

19. Direct students to review all of the cards and sort them into two new groups on their own. Students can use any characteristic, or trait, to sort the cards.
    - If students have difficulty choosing a characteristic, prompt them to think about habitats, body shape/structure, or diet that organisms can have.

20. Direct students to record how they grouped the Organism Cards on a sticky note or scrap paper. Have students place their notes on the board/chart paper under the "Round 1" heading.

> **Note**: In this activity, students should be grouping the organisms into categories that will help them define what it means to be a living thing. Living things all move (respond to stimuli), breathe, reproduce, excrete, grow, and consume. They may or may not have similar traits or structures that help them live.
>
> The names and categories that you record during the share-out from Round 1 can help students start to put these ideas into words and see the bigger picture. Some example groupings are:
> - Organisms that lay eggs versus Organisms that do not lay eggs
> - Organisms that are large versus Organisms that are small
> - Organisms that are predators versus Organisms that are prey
> - Organisms that chew versus Organisms that do not chew

21. Guide students to repeat the exercise but to sort the organisms into two new groups. Students cannot reuse their prior categories. After students write their new groupings on sticky notes or paper, direct them to keep it face down or hidden.

> **Note**: Students may also sort the organisms into three groups; for example, according to reproduction methods: hatches from egg, live birth, grows from seed.

22. Guide students to complete a Gallery Walk and observe how their classmates sorted the Organism Cards. Ask students questions about the unlabeled groupings during the Gallery Walk.

> - What groupings are you able to identify right away? Why do you think that is?
> - What groupings are more difficult to figure out? How did you figure them out?
> - Do you disagree with any groupings? Why? Make sure to share your evidence.
> - Why is it important to support your claims with evidence?

23. After the Gallery Walk, ask students to flip over their notes and share the names of their groupings with the class.

24. Lead students in a discussion based on the guiding questions from the Gallery Walk. If students want to challenge a grouping, ask them to provide evidence for that challenge.

25. As students share, record the names of the categories under the "Round 2" heading. Lead a discussion to reflect on the new groupings.

- Did our groupings get more complex in the second round? Why do you think that is?
- Were there any groupings that surprised you?
- How might you go about sorting the cards if we had a third round where you had to make three groups? Are there any new groups you can think of?

Part 3. Let's Answer the Question

26 Direct students to review the questions from Part 1 and their claims recorded in their Launch Logs. Guide students to revise their claims based on evidence gathered during this activity. Encourage them to review the categories from Round 1 and 2 as they consider how their answers may have changed.

27 Direct students to work with the same partner from Part 1 to write an evidence statement to the question, "What does it mean to be a living thing?" Ask partners to share their evidence statement and how it has changed. Students may find that they need to revise their claim based on the evidence they have gained throughout the activity.

28 As they share, create a chart of the characteristics of living things, and direct students to access the flashcard examples as you introduce the vocabulary terms *excrete*, *reproduce*, and *consume*:

- Move (swim, walk, creep, sway, respond to stimuli)
- Breathe (takie in gases and let gases out)
- Reproduce (eggs, seeds, live birth—discuss as you feel is appropriate)
- Excrete (discuss as you feel is appropriate)
- Grow (change shape, change size, age quickly, age slowly, metamorphize, produce many cells that do many different things)
- Consume (chew, photosynthesize, absorb nutrients, swallow)

29 Tell students that with a shared understanding of what makes living things the same, we can now investigate how organisms use very different structures to achieve the same goal: staying alive!

30 Guide students to answer the Conclusion Questions.

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 What characteristics do you and a tree have in common?

Student responses should demonstrate an understanding of the characteristics of living things. Responses might include:

Humans and trees both take in air. Humans and trees both grow. Humans and trees both consume food.

2 Choose two organisms from the Organism Cards that live in different habitats. Provide evidence that they are both living things, and provide one example of how they each survive in their habitats in different ways.

Student responses should demonstrate an understanding of the characteristics of living things (move, breathe, reproduce, excrete, grow, and consume). Responses might include:

Lobsters and hippos both move. A lobster moves in the water using its tail. A hippo moves on land by walking on its legs.

Activity 2

Structure and Function

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
• *Creature Features* by Steve Jenkins and Robin Page • Decorative leaves ◦ Pine branch leaves ◦ Broad leaf branch • Sifter • Small mirrors (one per center) • Food coloring • Paper towels • Clear plastic cups (4 or 5 per center) • String • Clothespins	• PLTW Launch Logs (one per student) • Digital devices • Fine Sand (1 lb) • Box or plastic tub • Baby carrots (1 or 2 per student) • Plastic sheeting or other protective cloth for surface • Scissors • Water • Rulers (3 or 4 per center) • Pencils or colored pencils for sketching • Chart paper • Markers	• Inkling • Chrome

ESSENTIAL QUESTIONS

EQ

EQ1 How are organisms structured to support and sustain life?
EQ2 How do scientists and engineers understand the world around them?
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.
LO1.3 Construct and/or support an argument with evidence, data, and/or a model.
LO2.1 Analyze how the functions of internal and external structures of selected plants and animals support survival, growth, behavior and reproduction.
LO4 Collaborate effectively on a diverse and multidisciplinary team.
LO5 Communicate effectively for specific purposes using the appropriate platform, tool, format, or digital media.
LO6 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.
KS1.3.2 Use data to evaluate claims of cause and effect.
KS1.3.3 Describe or predict natural phenomena using evidence and/or data.
KS2.1.3 Identify internal and external structures of plants and animals.
KS2.1.4 Describe the primary functions of internal and external structures of plants and animals.
KS2.1.5 Describe how plants and/or animals survive, grow, behave and reproduce..
KS2.1.6 Compare and contrast structures of plants and animals and how their structures and functions are similar or different.
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.

Introduction

Now that students have an understanding of what it means to be a living thing, they will learn about the wide variety of *structures* in animals and plants and how those structures *function* to support survival. The trunk of an elephant is no longer just a fun way to splash water, but a structure that helps the elephant stay cool and survive the harsh heat of the savanna. The waxy coating on a plant in a desert climate goes from potentially unnoticed to an obvious way to keep hold of precious moisture. By examining and investigating the structures and functions of living organisms, we learn to appreciate the countless unique solutions nature has created to keep plants and animals alive!

Preparation

Activity 2

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.

function	What something does or is intended to do.
scientific inquiry process	A process that scientists use to explore observations and answer questions.
structure	In living things, the arrangement of parts that form the organism.

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. Before you begin Activity 2, gather items needed 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 one pound of fine sand, baby carrots, a box or plastic tub, and plastic sheeting or other protective cloth for a surface.

> **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 the structure and function of organisms. It is important that each student visit every center to acquire the skills necessary for completing the Problem.

5. Set up each center as follows:
   - **Centers 1 and 5: Leaf Structure and Function**
     - Set up this center to allow students to observe the presentation of different leaves.
     - Materials: digital devices, decorative plastic leaves of varying shapes and sizes, including pine needles and broad deciduous leaves, fine sand, sifter, and box or plastic tub to catch the sand.
   - **Centers 2 and 6: Foot Structure and Function**
     - Set up this center to allow students to explore foot structures of different animals living in different habitats.
     - Review the **Foot Structures** interactive experience on a student device to make sure it works.

> **Note for iPad Users**: This interactive experience works best in the Chrome browser. If your students use iPads with Safari as the default browser, show them how to open the interactive experience in the Chrome app. To learn how, view the How to Open an Asset in Chrome on an iPad presentation.
>
> 
>
> How to Open an Asset in Chrome on an iPad presentation

     - Materials: digital devices.
   - **Centers 3 and 7: Teeth Structure and Function**
     - Set up this center so students can investigate the different function of human teeth and compare this to different animals' teeth.
     - Materials: digital devices, baby carrots, mirrors.
   - **Centers 4 and 8: Internal Plant Structures and Function**

- Students may need guidance for this center. Ask an adult to assist with this center to provide a demonstration and guidance for students.
- Set up this center to allow students to investigate how internal plant structures transport water up the stem of a plant.
  - Prepare different size strips of paper towels of the same length but varying widths
  - Prepare 4 or 5 cups of water with food coloring added.
  - Lay down plastic sheeting or other protective gear to protect surfaces.
  - Cut the string to 8 feet long. (Optionally, you may cut the string into two 2-foot sections to have two clotheslines.)
  - Tie each end of the string to a solid sturdy object to create a clothesline that hangs above the cups. The height of the clothesline should be approximately the same height as the paper towel strips.
  - Place several clothespins at the center to attach the paper towel strips to the string over the cups of water.
- Materials: digital devices, cups, paper towels, food coloring, water, rulers, scissors, string, sturdy objects to tie each end of the string to, clothespins, plastic sheeting or other protective cloth for a surface.

6. To become familiar with the student procedure for each center, review the center pages in the student course.
7. Students use the Scientific Inquiry Process in the project. Review the Scientific Inquiry Process video before you facilitate Activity 2.
8. Review the book *Creature Features* by Steve Jenkins to become familiar with the content.

Possible Student Misconceptions

- **If two structures are similar, they must do the same thing**. Animals can have similar structures but use them for different functions. For example, the function of a beak is not the same for every bird. The sharp curved beak of a bird of prey is used for ripping or tearing, while seed-eating birds have a short, cone-shaped beak for picking up and crushing seeds.
- **Leaves fall because they get too heavy**. Broad deciduous leaves, should they remain on a tree into snowy weather, do not have a design that allows them to bear the weight of snow or ice build up and can be damaged or torn from a branch as a result. Deciduous trees purposefully shed their leaves in the fall before significant cold weather to conserve water and energy, not because weather forces the leaves to fall.

Procedure

Time: 110 Minutes

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. 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 the function of animal structures.
4. Guide students to view the **Scientific Inquiry Process** video as an introduction to scientists and the scientific inquiry process.
5. 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 introduce 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?

6. Explain that students will work in small groups to investigate the way varied plant and animal structures function.
7. Direct the students to access the flashcard example as you introduce the vocabulary terms *structure* and *function*.
8. Lead a discussion about the terms structure and function.

   - What structures did you identify while sorting the Organism Cards in Activity 1? What functions did those structures have?
   - Can you think of a structure that all animals have in common? One that all plants have in common?
   - How did you arrive at that conclusion?

9. Students will rotate through four centers. At each station, students will follow the same process:
   - Direct students to first **ASK** the guiding question for the center.
   - Students use the resources or information provided to **PREDICT** an answer to the question.
   - Students will follow the directions to **INVESTIGATE** the structure and **OBSERVE** how it functions.
   - Students will answer the question and **EXPLAIN** their answer.
10. Introduce and model each of the following centers for the students. Students access the procedure steps on each center page in the student course.

- The first step at each center is for students to create a chart specific to that center. Each step should be documented in students' Launch Logs.

Steps	Name of Center
Ask	
Predict	
Investigate and Observe	
Explain	

- **Centers 1 and 5: Leaf Structure and Function**
  - Students explore the leaf structure presentation to learn about different structures of leaves. Next, students investigate what happens to a simulated pine needle versus a simulated deciduous leaf when simulated snow (fine sand) falls on it. They predict what the best structure for a leaf is that needs to withstand snow.
- **Centers 2 and 6: Foot Structure and Function**
  - Students explore the foot structure presentation to learn about different structures of birds feet. Next, students investigate how the structure of a bird's foot matches its habitat; they engage in an interactive experience looking at images of a variety of birds and their feet and matching them to their likely habitats.
- **Centers 3 and 7: Teeth Structure and Function**
  - Students explore the teeth structure presentation to learn about different types of human teeth.
  - Direct students to wash their hands before eating.
  - Next, students investigate their own teeth and how they function by eating a carrot. Students compare the structure and function of their teeth to the teeth of several animals to draw conclusions about teeth and diet.
- **Centers 4 and 8: Internal Plant Structures and Function**
  - Students engage in an interactive experience to learn about the internal plant structures. Next, they investigate how internal plant structures transport water up the stem of a plant by observing how a paper towel strip absorbs colored water from a cup.

11 Direct students to spend 10–15 minutes at each center. As students rotate through the four learning centers, observe students interacting with each structure. Use the guiding questions to help students understand the structures.

- What is the name for the structure you are exploring? Are there similar structures on another living organism?
- Does this structure and its function match a function you need as a human?

Note: For the Leaf Structures Center: If needed, direct students to notice that sand builds up on broad leaves and bends them as weight builds, while sand will easily fall off a pine needle. The pine needle will never break under the weight of winter snow. Clarify that deciduous leaves do not need to withstand snow, but by examining how their structure performs in snow, we gain a better appreciation for the effective design of the pine needle.

12 Lead a class discussion about the learning centers. Direct students to write their own responses to the questions in their Launch Logs.

- What connections did you make between plant and animal structures and how the structures fulfill a special need for their living organism?
- What evidence do you have that shows how structures have been formed to complete a specific function?

13 To share additional real-world examples, read aloud the book *Creature Features* by Steve Jenkins. This picture book shares 25 examples of real animals and their unique structures. The function of each animal's unique structure is explained.

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

Conclusion Questions Answer Key

1 Choose an animal. Using evidence from structures on the animal other than its teeth, what do you think its diet is?

Student responses should demonstrate an understanding of the functions of different structures. Responses might include:

A giraffe's diet consists of leaves and other plants. Its neck and legs are long and tall to reach leaves on tall trees.

A cheetah's diet consists of meat. Its body is built for speed to chase and capture live prey.

2 Living things must be able to respond to their environment to survive. Describe what an organism might do when its environment doesn't provide enough food.

Student responses should demonstrate an understanding of the fossils and habitats. Responses might include:

If a plant or tree did not receive enough water, it might stretch its roots in new directions to search for water.

A bird could use its wings to fly to a new location that provides enough food.

In the winter, food is scarce for a bear. A bear's body is made to hibernate to keep the bear alive during this time.

Activity 3

Systems

Teacher Resources

View Student Course

EQUIPMENT

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

Not Included in Equipment	Device Applications
• PLTW Launch Logs (one per student) • Digital devices • Assorted books (3 per pair of students) • Clean socks or plastic or paper bags (2 per pair of students) • Blindfolds or clean handkerchiefs (1 per pair of students) • Pencils or colored pencils for sketching • Chart paper • Markers	• Inkling • ShowMe Interactive Whiteboard

RESOURCE

R

Systems of the Human Body Transcript

ESSENTIAL QUESTIONS

EQ

EQ1 How are organisms structured to support and sustain life?
EQ2 How do scientists and engineers understand the world around them?
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.
LO1.3 Construct and/or support an argument with evidence, data, and/or a model.
LO2.1 Analyze how the functions of internal and external structures of selected plants and animals support survival, growth, behavior and reproduction.
LO2.2 Analyze how different structures work together as part of a system to support survival, growth, behavior and reproduction.
LO4 Collaborate effectively on a diverse and multidisciplinary team.
LO5 Communicate effectively for specific purposes using the appropriate platform, tool, format, or digital media.
LO6 Practice ethical behavior in all settings.

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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.
KS1.3.1	Draw or sketch accurate representations to convey ideas.
KS1.3.2	Use data to evaluate claims of cause and effect.
KS1.3.3	Describe or predict natural phenomena using evidence and/or data.
KS2.1.3	Identify internal and external structures of plants and animals.
KS2.1.4	Describe the primary functions of internal and external structures of plants and animals.
KS2.1.5	Describe how plants and/or animals survive, grow, behave and reproduce..
KS2.2.1	Describe the components of a system and their interactions.
KS2.2.2	Recognize that a system is composed of multiple components that work together.
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.

Introduction

It is easy to look at a living organism and identify the *structures* that are important for staying alive, such as the brain or the hands or the mouth. But these structures do not work on their own. Biological structures work together to form complex *systems*. These systems support *functions* that enable an organism to survive.

In this activity, students explore how an organism's structures relate to its systems and functions.

Preparation

Professional Development

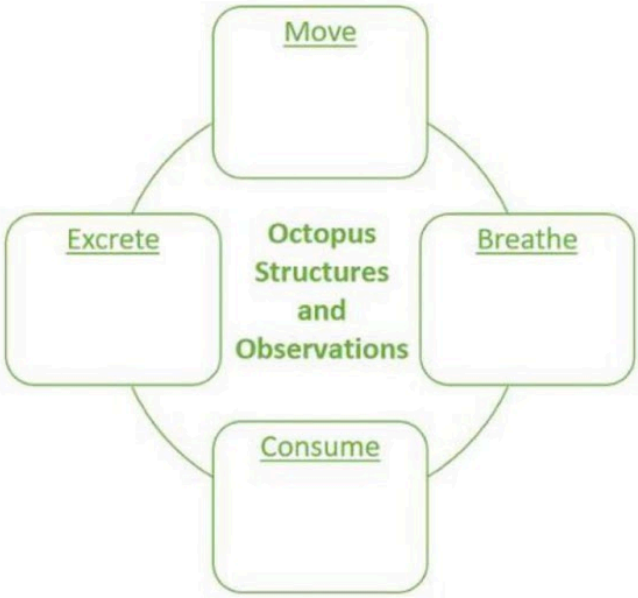
Before you facilitate Activity 3, access the **Organisms: Structure and Function Module-specific PD Resources** to review Building Your Understanding: Body Systems.

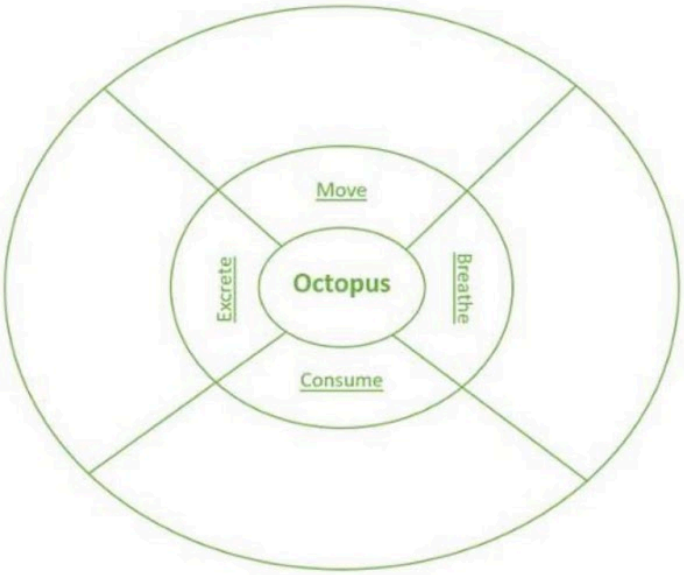
Part 1. The Unique Structures of the Octopus

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.

function	What something does or is intended to do.
structure	In living things, the arrangement of parts that form the organism.
system	A group of structures that work together to carry out a specific task.

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. Preview the octopus videos and **Octopus Structures** interactive experience to become familiar with the content. Review the discussion questions in the Procedure.
5. In this activity, students create a graphic organizer in their Launch Logs to record notes about how an octopus interacts with its environment. If students are not familiar with using graphic organizers, create an example on chart paper or the ShowMe Interactive Whiteboard app to use as you introduce this idea to students. Possible graphic organizers:





Structures an Octopus uses to:	Observations
Move	
Breathe	
Consume	
Excrete	

6. Decide how you want to divide the class into groups of four students. Within each group, assign each student one of the four scenarios. For example, have members of each group count off a, b, c, d and assign them the corresponding scenario:
   a. An octopus swimming in open water is approached by a predator.
   b. An octopus swimming along the bottom of the ocean in a coral reef is approached by a predator.
   c. An octopus is hunting a shrimp.
   d. A hungry octopus discovers a clam in its shell.

Part 2. Human Systems Working Together

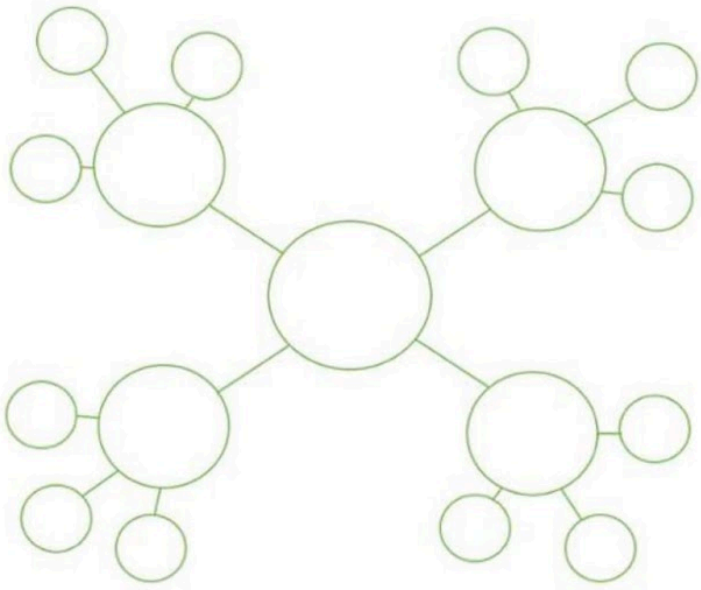
1. Gather materials for students to complete the tasks. Each pair of students needs the following materials:

- Three books to lay end to end and then stack.
- Two clean socks or paper or plastic bags to place over their hands.
- A blindfold or clean handkerchief

2. Preview the **Systems of the Human Body** interactive experience to become familiar with the content. Alternatively, you can view the transcript in the Resources box. The student course also includes a link to the transcript.
3. Review the discussion questions in the Procedure.

> **Note: Sensitively Addressing Visual or Physical Impairments in Your Class**
>
> Activity 3, Part 2 provides opportunities to increase disability awareness. As you prepare to facilitate the Tasks in Part 2, thoughtfully consider these sensitive topics. As a first step, review the information shared here and plan your implementation strategy.
>
> Before you begin this activity, connect with a special education expert in your school. This individual will be able to provide support and information unique to your students and local school community. If you have a student with visual or physical impairments in your class, communicate privately in advance with the student, their parents or guardian, and a special education teacher.

4. Students will be asked to create a mind map as they watch the Human Systems Interactive Experience. If students are not familiar with using mind maps, create an example on chart paper or the ShowMe Interactive Whiteboard app to use as you introduce this idea to students.



Possible Student Misconception

Every structure in or on a human body is vital. Out of all of the body parts in the human body, only five are considered vital. These vital organs are crucial to survival, meaning we could not survive without them. They are the brain, heart, kidneys, liver, and lungs.

Procedure

Time: 110 Minutes

Part 1. The Unique Structure of the Octopus

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. Review structure and function.

- Does each structure in the human body have a unique function? Support your claim. Direct students to access the flashcard examples as you review the terms *structure* and *function*.
- How do structures meet the needs of living organisms?
- What structures do you think all animals share? Support your answer with evidence.

4. Guide students to view the Animal Structures presentation to learn more about animal structures.
5. Lead a discussion about animal structures and their functions.

- Why is it important for animals to move, or respond to stimuli? Support your claim with evidence.
- How does this connect to your life?
- Think of an animal. What structures function as sensory input for this animal? If the structure did not function correctly, how might this impact the animal? Why do you think that?
- Why do you think there is so much variety in structures among animals and how they function? Support your claim with evidence.

6. Have students create a graphic organizer in their Launch Logs in preparation to watch the videos of an octopus interacting with its environment.
7. Direct students to watch the octopus videos. Explain that students will apply their knowledge of structure and function as they observe how an octopus uses its structures. As students watch the videos, they take notes on their graphic organizer in their Launch Logs.
8. Explain that students will learn more about the structures of an octopus by exploring the **Octopus Structures** interactive experience. Direct students to continue to add to their graphic organizer information about the structures of an octopus and how they function.
9. Lead a discussion about students' observations.

- Identify the structures the octopus uses to eat. Explain how these structures function to allow the octopus to eat.
- Identify the structures the octopus uses to move. Explain how these structures function to allow the octopus to move.
- Identify the structures the octopus uses to protect itself. Explain how these structures function to allow the octopus to protect itself.

10. Explain that students will use what they have learned about octopi to predict what an octopus would do in different scenarios.
11. Tell students their groups and scenarios you assigned in Preparation.
12. Guide students to take notes on their scenario using the procedure in the student course. Direct students to organize their response to their assigned scenario in the following way in their Launch Log:

Scenario Write the scenario you are assigned.
Scenario Narrative Write the story of the octopus' actions in the scenario. Write it descriptively, as if you are a biologist taking detailed notes of an animal's behavior and you cannot miss a single detail!
Structures Write out the specific structures the octopus will rely on in your scenario. If it helps, draw pictures with labels and notes that describe the interactions.

13. After each student takes notes on their assigned scenario, direct them to share their scenario narrative and structures with their group. Model how to give positive feedback and constructive comments for the groups, so each person sharing receives compliments and comments on things they may have missed.
14. Lead a whole class discussion about the students' conclusions.

- Which functions did the octopus do using only one structure?
- Which functions required multiple structures?
- How did the structures work together to help the octopus meet its needs?

Part 2. Human Systems Working Together

15. Inform students that they will work with a partner to complete a series of tasks to explore different structures of the human body.
16. In their Launch Logs, guide students to create the Task tables to record their observations for this activity.
17. Guide pairs of students to complete the three tasks.
18. Lead a discussion in which students reflect on the Tasks.

- Which task did you feel you performed the best? Why do you think this?
- Did you adapt to each task so you were still able to accomplish it? Did you use new structures when faced with a new challenge?
- If you had to continue the task without fingers, how might your body adapt?
- How did eliminating your sight affect your ability to complete the task?

19 Direct students to refer to their Launch Log notes from Activity 1 and Activity 2 to review the characteristics of living organisms. Students learned that living things have structures that function in different ways to meet their needs.

20 Guide students to use their Launch Log notes along with data from their tables to make a claim in response to the question: What structures in your body worked together for you to perform the task?

21 Have students write their claim in their Launch Log and include one piece of evidence to support their claim. Potential responses include:

- **Claim:** My arms and fingers worked together.
- **Evidence:** I used my fingers to wrap around the books, and the muscles in my arms lifted the books.

- **Claim:** My eyes and brain worked together.
- **Evidence:** My eyes took in the information that my brain used to know where to direct my arms.

22 Explain that when structures work together, they are called a system. Direct students to access the flashcard example as you further discuss the vocabulary term *system*.

23 Lead a discussion about systems.

- Which structures do you think work together in your body? What systems do you think are necessary to keep you alive? Why do you think that?
- How did systems change or adapt during the task when certain structures were no longer available?
- What are other examples of how systems in your body can adapt?

24 Introduce the **Systems of the Human Body** interactive experience. Alternatively, students may review the transcript of this information. Guide students to work with a partner or small group to view the presentation to build an understanding of the systems in the human body and how the different internal structures of the human body work together to complete a function. Direct students to take notes in their Launch Logs using a mind map.

25 Provide a sample or instructions for creating a mind map.

26 Lead a discussion about the presentation.

- Think about each of the systems described. How were these systems used to complete the tasks earlier in this activity?
- Describe the steps you go through to get ready for school in the morning and explain the systems involved in each step.

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

Conclusion Questions Answer Key

1 Look at the image of the elephant's trunk. What do you think the functions of the trunk are? What systems do you think the trunk is a part of? Support your ideas with evidence.



Student responses should demonstrate an understanding of the structure, function, and systems. Responses might include:
Elephants can breathe through their trunk, which means it is part of the respiratory system. The trunk can curl and grab things, which means it has muscles and is part of the skeletomuscular system. It can smell and move food to the mouth, so it is an important part of providing an elephant with food to grow and survive.

2 Look at the picture of the flowering cactus. Externally, a cactus has spines, flowers, and tough, thick walls. Internally, a cactus moves water and nutrients throughout its body using xylem and phloem. How do these structures create a system or systems that supports the cactus' survival?



Student responses should demonstrate an understanding of how structures create a system that supports the cactus' survival. Responses might include:

The spines and thick walls work together to prevent animals from eating the plant for its water, while the roots, xylem, and phloem work to move water and nutrients into the plant for storage in a hot desert. These structures make a system that keeps the plant alive. If the plant can stay alive in the desert, its flowers will be pollinated and create seeds that will spread and produce more cacti.

Project

Design a Plant

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
• Organism Cards • Tape	• PLTW Launch Logs (one per student) • Digital devices • Sticky notes or scrap paper • Crayons, pencils or colored pencils for sketching • Chart paper • Markers	• Inkling

ESSENTIAL QUESTIONS

EQ

EQ1 How are organisms structured to support and sustain life?
EQ2 How do scientists and engineers understand the world around them?
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.
LO1.3 Construct and/or support an argument with evidence, data, and/or a model.
LO2.1 Analyze how the functions of internal and external structures of selected plants and animals support survival, growth, behavior and reproduction.
LO2.2 Analyze how different structures work together as part of a system to support survival, growth, behavior and reproduction.
LO4 Collaborate effectively on a diverse and multidisciplinary team.
LO5 Communicate effectively for specific purposes using the appropriate platform, tool, format, or digital media.
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	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.
KS1.3.1	Draw or sketch accurate representations to convey ideas.
KS1.3.2	Use data to evaluate claims of cause and effect.
KS1.3.3	Describe or predict natural phenomena using evidence and/or data.
KS2.1.3	Identify internal and external structures of plants and animals.
KS2.1.4	Describe the primary functions of internal and external structures of plants and animals.
KS2.1.5	Describe how plants and/or animals survive, grow, behave and reproduce.
KS2.2.1	Describe the components of a system and their interactions.
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.

Introduction

It is easy to see that not all plants are the same: a cactus that lives in the desert has very different *structures* from a fern that lives in the rain forest. Each plant's unique structures help it survive in its specific *environment*. In this project, students are challenged to design a fictitious plant given a specific scenario for how it needs to grow and survive in its environment.

Preparation

Part 1. Plant Structures and Systems

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.

consume	To take in (eat or drink) something as food.
constraint	A limitation or a restriction. Constraints include limits on time, materials, and size.
criteria	Guidelines or rules used to make a decision about something.
design process	A step-by-step way to solve problems.
environment	The living things, nonliving things, and conditions in an area.
excrete	To remove or eliminate waste.
function	What something does or is intended to do.
model	A copy of an object that can be smaller or larger than the original.
structure	The arrangement of parts that form the organism.
system	A group of structures that work together to carry out a specific task.

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. Using the Organism Cards, separate the plant cards for students to use in the project.
5. Use nine pieces of chart paper to create charts with the following headings:
   - Plant Structures
   - Plant Systems
   - Consume
   - Excrete
   - Move
   - Grow
   - Reproduce
   - Unique to Environment
   - Plant and Animal Systems Compared
6. Tape the chart papers around the room for students to record their thoughts.

Part 2. A Fictitious Plant

1. Plan which scenario you will assign partner groups.
   a. Resists herbivore predation.
   b. Survives in dry soil.
   c. Obtains sunlight in a shady area.
   d. Survives in a cold, snowy climate.
   e. Attracts pollinators in a field of flowers.
   f. Reproduces in an area crowded with plants and no open ground.
2. As an extension, you may have students create their fictitious plant using:
   - apps such as, ScratchJr, ShowMe Interactive Whiteboard, or Popplet Lite
   - available craft materials

Possible Student Misconceptions

- **All plants have flowers with petals, green leaves, and a stem.** The structures that all plants have in common are two main systems: the shoot system and the root system. Many plants, such as a pine tree, never grow flowers or petals. Moss is a plant but it has no stem or leaves.
- **Plants get their food from the soil.** Plants do not "eat." They take in water, carbon dioxide, and light from the sun to make their own food using a process called photosynthesis. The soil can provide additional minerals and nutrients for plants, but soil is not necessary for growth.

Procedure

Time: 120 Minutes

Part 1. Plant Structures and Systems

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. Review what students have learned so far in the module. Direct students to access the flashcard example as you review the vocabulary terms *structure* and *function*. Remind students that organisms have different structures that help them survive and these different structures function together as a system. For many organisms, the structures that help them survive reflect adaptations based on their environment.
4. Direct students to access the flashcard example as you review the vocabulary term *environment*.
5. Direct students to view the Plant Structures presentation to learn more about the wide variety of plant structures.
6. Lead a discussion about plant structures and their functions.

   - What are some different ways plants are structured to absorb the amount of sunlight they need? Support your claim with evidence.
   - What do you think would happen if all plants had the same structures? How would this impact their survival? Explain your thinking.
   - Why do you think there is so much variety in structures among plants? Support your claim with evidence.

7. Direct students to work in small groups to examine specific plant structures. Give each group a set of plant Organism Cards. Direct small groups to do the following:
   - Identify and record as may different structures as they can find for each of the plants.
   - Make a claim about the purpose of each structure and use details from the structure as evidence.
   - Predict the environment each plant might live in and draw a star next to structures that allow plants to survive in a specific environment. Predict how these structures would help the plant survive in that specific environment.
8. Direct students to access the flashcard example as you review the vocabulary term *system*.
9. Ask students to think back to the animal systems from Activity 3. Discuss these systems and ask students to make predictions about similar systems in plants.

   - Animals can have skeletal systems to support their bodies. Do plants have a similar system? Support your claim with evidence.
   - Animals have systems to eat and process food. Do plants have a similar system? Why do you think that?

10. Direct students to return to the plant Organism Cards and identify and record plant systems they think help the plant survive. Identify the structures in the system. Write a prediction about the purpose of each system and use details from the structure as evidence.
11. Direct students to access the flashcard examples as you introduce the vocabulary terms *consume* and *excrete*.
12. Direct students to use their notes, the Organism Cards, and any presentations in the module to answer the following questions on sticky notes or scrap paper.

- What structures did you find that allow a plant to consume?
- What structures did you find that allow a plant to excrete?
- What structures did you find that allow a plant to move?
- What structures did you find that allow a plant to grow?
- What structures did you find that allow a plant to reproduce?
- What structures were unique to specific environments? Share your evidence.
- What plant systems were you able to identify that help a plant survive? Which structures were in the system?
- How do these systems compare to systems found in animals?

Note: Students should be able to refer to the Activity 2 exploration of plant tissues that move water and nutrients through the plant to offer a predicted system. Water is moved through multiple structures (roots, xylem in the stem, and leaves) throughout the plant to help it survive. Through this discussion, ensure students have a clear understanding of this simple system and the structures involved.

13 Direct students to place their notes on the appropriate chart papers around the room. Provide tape to students if using scrap paper.

14 After the students have completed recording their thoughts on the chart paper, lead a discussion about their notes on each chart paper. Address any misconceptions students have at this time.

Part 2. A Fictitious Plant

15 Introduce the design process that students will use to guide their work on solving the problem.

- 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.

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



Design Process video

17 Lead a discussion about what students learned from the Design Process video. Ask students the following questions:

- Why do engineers use the design process? Direct students to access the flashcard example as you review the vocabulary term *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.

18 Guide students to create a graphic organizer of the Design Process in their Launch Logs. They will use this organizer to take notes as they design a plant to survive in an assigned scenario.

19 Ask students where they have seen a small version of a life-size object. Examples include a toy car, toy truck, doll, or a globe. Use the flashcard example to introduce the vocabulary word *model*. Inform students that they will be designing a plant model for their assigned scenario.

20 Tell pairs of students which scenario they are assigned. Inform them that this will be the main focus of their fictitious plant design.

a. Resists predators that are herbivores.
b. Survives in dry soil.
c. Obtains sunlight in a shady area.
d. Survives in a cold, snowy climate.
e. Attracts pollinators in a field of flowers.
f. Reproduces in an area crowded with plants and no open ground.

21 Introduce the idea of defining *criteria* and *constraints* to provide guidelines for their work. Direct students to access the flashcard examples as you introduce the vocabulary terms *criteria* and *constraint*.

22 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.

Criteria	Constraints
The plant model: • Fulfills the purpose of your scenario • Has a full picture of the plant, including the basic plant structures of roots, stem, and leaves, and any additional structures required to solve the problem • Labels all structures the plant uses to survive and describes the function of each structure • Includes a descriptive paragraph that presents a claim as to why the design meets the needs of the plant, with a specific focus on the evidence that demonstrates how plant structure addresses their unique scenario	• Time • Materials

- With support and guidance, the students define the problem, "What structures does a plant need to be able to _____?"
- Guide the students in a discussion to consider the problem, criteria, and constraints.

  - What is a structure that you will need to represent in your model? How can you make sure this structure is clearly demonstrated?
  - We cannot build actual plants, but our picture models can be detailed. What do you think a detailed picture model needs?

- Guide students to record their responses in the Ask section of their graphic organizer in their Launch Logs.

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

- Introduce the Explore step of the design process as a time to explore possible solutions to the design problem. Remind students to use the Explore section of the Launch Log to record their ideas throughout this step.
- Guide students to brainstorm possible solutions to the question and consider the different plant structures they examined in Part 1. Remind students that the plant must also have the structures it needs to be a fully functioning plant in all other ways required to survive. Encourage students to use the skills and knowledge they gained from the activities in this module as they brainstorm.
- In the corresponding section of their graphic organizer, direct students to record ideas and label sketches for their model. Sketches should be based on knowledge about plant structures and systems from previous activities. For each sketch, direct students to write a sentence justifying the potential solution to the problem.
- Guide students to share their initial ideas with their partner. Encourage them to add any new ideas by writing or sketching in their Launch Logs.

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

- Review the Model step of the design process. In this step, students make a decision about the best design for their fictitious plant, and then they design the plant using the criteria and constraints as a guide.
- Guide students to use the chosen idea to develop a plan for their design.
- Direct students to the materials available (markers, crayons, colored pencils, etc.). Guide pairs to draw their fictitious plant model.
- As students develop their model, provide guidance as needed to help students build their ideas using the criteria and constraints for the problem.
- Assess student progress in applying what they have learned about plant structures and functions in their design.
- To facilitate the model creation, circle around the room, spending time with the partners, providing support, and allowing students to share their thinking as they work. This allows you to assess:
  - Student demonstration of conceptual understanding
  - Problem-solving skills
  - Collaborative skills

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

- Review the Evaluate step with students. Remind them that this valuable step allows them to assess how well they have solved or not solved the problem.
- Guide students to view their model and reflect on its strengths and weaknesses. Have them consider:
  - Would the model survive in the assigned scenario?
  - Does the model meet the criteria for the design?
  - What can you do to improve your model?

- Have students partner with another group to complete a cross-team review. Guide each group to present their picture and paragraph of their fictitious plant model and provide constructive feedback on how to improve.
- After students identify the strengths and weaknesses of their model and complete a cross-team review, provide time for them to iterate on their design to ensure it successfully solves the design challenge.

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

- Direct students to set their picture model and explanatory paragraph out on their desk. Distribute sticky notes or scrap paper to each student.
- Direct students to conduct a gallery walk of the models to review other students' models and justifications (consider limiting to five other students). Direct students to use a sticky note or scrap paper to share one way that you believe the model solved the problem, and make one suggestion for how to improve the model. Each student should receive feedback from at least four other students.
- Ask students to review the feedback their classmates gave.
- Lead a discussion about the features, strengths, and weaknesses of the different models.

  - In what ways did your model meet the criteria?
  - How was your model similar to the models of students with the same scenario? Did anyone solve it in a different way?
  - Why is it important to get feedback from others?
  - What did you learn about your model from the feedback you received? How could this feedback help you improve your model?

- Guide students to complete the Explain section of their graphic organizer in their Launch Logs. Have students provide suggestions for improvement for their models and support those with evidence.

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

Conclusion Questions Answer Key

1 On your walk home, you notice that a plant is struggling to survive while all the plants around it appear to be healthy. Explain how you could use your knowledge of plant structures and systems to evaluate the plant for problems.

Student responses should demonstrate an understanding of how plant structures and systems play a role in keeping the plant alive. Responses might include:

I can look to see if the plant is getting enough sun on its leaves.

I can look for signs that any animals are eating or harming the plant on its leaves and stem.

I can check the soil to see if it is too dry. I can look at a stem, branch, or leaf for wilting. If these structures are drooping, the xylem and phloem do not have enough water or nutrients moving through them.

I can look at the roots to see if they have room to spread out.

2 Select a different scenario from the project. How would you design a plant to survive in this new scenario?

Student responses should demonstrate an understanding of how plant structures and systems can work in different ways to help a plant survive in varying circumstances. Responses will vary based on the survival criteria chosen.

Problem

Animal Prosthesis

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
• *Pierre the Penguin* by Jean Marzollo • Foam Sheets • Aluminum foil • Plastic wrap • Tacky glue • Tape • Feathers • String • Pipe cleaners • Craft sticks • Modeling clay • Felt • Wooden dowels • Bamboo skewers • Toothpicks • Glue gun/sticks	• PLTW Launch Logs (one per student) • Digital devices • Pencils or colored pencils for sketching • Chart paper • Markers	• Inkling • Digital product apps, such as: ◦ Video function on device ◦ Popplet Lite ◦ Mindomo ◦ ShowMe Interactive Whiteboard ◦ Quik ◦ TwistedWave

RESOURCES

R

Research Resources

Decision Matrix

Summative Assessment

ESSENTIAL QUESTIONS

EQ

EQ1 How are organisms structured to support and sustain life?

EQ2 How do scientists and engineers understand the world around them?

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.

LO1.3 Construct and/or support an argument with evidence, data, and/or a model.

LO2.1 Analyze how the functions of internal and external structures of selected plants and animals support survival, growth, behavior and reproduction.

LO2.2 Analyze how different structures work together as part of a system to support survival, growth, behavior and reproduction.

LO3 Apply mathematical thinking to solve problems.

LO4 Collaborate effectively on a diverse and multidisciplinary team.

LO5 Communicate effectively for specific purposes using the appropriate platform, tool, format, or digital media.

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	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.
KS1.3.1	Draw or sketch accurate representations to convey ideas.
KS1.3.3	Describe or predict natural phenomena using evidence and/or data.
KS2.1.4	Describe the primary functions of internal and external structures of plants and animals.
KS2.1.5	Describe how plants and/or animals survive, grow, behave and reproduce.
KS2.2.1	Describe the components of a system and their interactions
KS3.1	Make sense of problems and persevere in solving them. [CCSS.MATH.PRACTICE.MP1].
KS3.2	Construct viable arguments and critique the reasoning of others. [CCSS.MATH.PRACTICE.MP3]
KS3.3	Use appropriate tools strategically. [CCSS.MATH.PRACTICE.MP5]
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.

Introduction

In this problem, students follow the *design process* to design, build, and evaluate a model of a *prosthesis* to help an injured animal survive by being able to move or eat again.

During the Explore step of the design process, students will research the specific animal structure they will recreate with a prosthesis to learn how this *structure functions* and to better understand how their prosthesis must work.

During the Explain step of the design process, students will create a presentation to share their prototype and explain how the structure of the prosthesis works with the organism's other structures as a system to promote the animal's survival.

Preparation

Professional Development PD

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 vocabulary terms used in this problem. Plan how you will help students use these terms as part of their vocabulary.

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.
function	What something does or is intended to do.
prosthesis	An artificial body part.
structure	The arrangement of parts that form the organism.

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. Review the original design problem introduced in the Introduction Story: *Animal Patients*.
5. Students use the ShowMe Interactive Whiteboard, Popplet Lite, or Mindomo to create a presentation. If students are unfamiliar with these presentation apps, introduce the app(s) they will use to create their presentations, before you begin the problem.
6. Review the book *Pierre the Penguin* by Jean Marzollo and prepare questions for discussion.
7. In the student course, review A New Kind of Leg. Consider ways that you can help interested students learn more about the field of prosthetics.
8. Review the **Research Resources** and select books, websites, articles, and other material students can use to do research during the Explore portion of the design process.
9. Determine what students will use to build and test their models. Options:
   - Students can use themselves as models to build and test the design.
   - Students can bring in stuffed animals that represent or are similar to the injured animal to build and test the design on.
   - Identify other objects students could use to represent the injured animal to build and test their design on.
10. Plan how to create pairs (based on animal choice) for this problem.
11. Plan how to create small groups for the Evaluate step of the problem. Groups should include four pairs of students, each working on a different animal prosthesis.
12. Plan for an adult to operate the glue gun during the facilitation of the problem.
13. Gather materials and equipment and prepare a supply table or plan how you will distribute supplies to students.
14. As students work through the design process to develop a model animal prosthesis, use the Organisms: Structure and Function 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 for assessment throughout the process of solving the problem.
15. 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 Misconceptions

- **Once an animal receives a prosthesis, it can easily go back to its normal functions for the rest of its life**. An animal needs training and support to make the best of their new prosthetic. Also, no living thing keeps its exact same body composition or shape as it ages. A prosthetic has to be adjusted or redesigned over the life of an animal to keep it functioning properly.
- **Animals with prostheses were hurt by other animals or humans**. While this does happen, animals can also be born with defects to important body structures or defects can develop later in life.

Procedure

Time: 180 Minutes

1. Direct students to access the problem in the student course and have them read the Introduction. As you guide them to review the problem statement, allow students to share their thoughts and excitement about designing an animal prosthesis for one of the injured animals from the Introduction Story.
2. Direct students to access the flashcard example as you review the vocabulary terms *structure* and *function*.
3. Lead a discussion to review animal structures and their functions.

   - Why are structures important for animals?
   - If a structure is not functioning correctly, how might this impact an animal?

4. Explain to students that they are going to use the design process to design, build, and evaluate a model a prosthesis to help an injured animal move or eat again.
5. Lead a discussion about prostheses.

   - What is a prosthesis? Direct students to access the flashcard example as you introduce the vocabulary term *prosthesis*.
   - Why might living things need a prosthesis?

6. Direct students to view the Living with a Prosthesis presentation to learn more about prostheses.
7. Guide students to read A New Kind of Leg, which reveals why and how the first prosthetic blade was designed.
8. Lead a discussion with students.

   - What do you notice about the blade's design?
   - What do you wonder about the field of prosthetics? How can you learn more?

9. Direct students to access the flashcard example as you review the vocabulary term *design process*.
10. Review the Design Process video with students, if needed.
11. 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 create their prototype. Remind students to include details that provide evidence for their thinking.
12. The first step in the design process is **Ask**.
    - Guide a discussion where students ask questions to gather information that will help them define and understand the problem.
    - With support and guidance, the students define the problem, "How do I design a model prosthesis to help an injured animal survive in its natural habitat?"
    - Use the flashcard examples to review the vocabulary terms *criteria* and *constraint*.
    - Introduce the criteria and constraints of the design.

Criteria	Constraints
The model: • Mimics the injured body part. • Supports the function of the injured body part and works as part of related animal systems. • Appears to be comfortable and is not too heavy. • Is removable.	• Time • Materials • Lack of live animals to help with testing

    - Guide the students in a discussion to consider the problem, criteria, and constraints.

- Discuss what mimic means. Does the prosthesis need to be an exact copy to restore function for the animal or will a similar design work?
- Why is it important to restore function for the animal?
- What might happen if a prosthesis does not fit comfortably on an animal?

- 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.

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

- Direct students to select which animal from the Introduction Story they want to design a prosthesis for and then pair students with the same animal choice.
- Guide students to observe the illustrations of the injured animals in the student course. Explain how each illustration shows the part of the animal where their injury occurred and that students will need to demonstrate how their model prosthesis fits and is designed to comfortably attach to the animal.
  - dolphin (tail)
  - eagle (beak)
  - turtle (two front legs)
  - robin (wing)
- Read the book *Pierre the Penguin* by Jean Marzollo aloud for students. You may choose to use a document viewer to project an image of the book.
- Guide pairs to discuss what happened in the book, with their animal in mind.

- How did Pam and her friend use their knowledge of structure and function to help Pierre? What do you know about the structure and function of your animal's injured body part?
- Pam got inspiration to help Pierre from a raincoat on her dog. Where could you look for inspiration to help your injured animal?

- Direct students to examine the illustration of their chosen injured animal.
- Guide students to conduct research to learn about real animals with similar challenges that were helped by scientists and engineers who designed prostheses for them. See **Research Resources** for research options. Direct students to look for:
  - Examples of prostheses that restored full function to an animal and those that only restored partial function.
  - Examples of how the prosthesis allows an important animal system to return to proper functioning.
  - The materials used to construct prostheses and the environments they have to withstand (rain, submerged in water, extreme heat or cold).
- 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.
- In the corresponding section of their Launch Logs, students record ideas for their solution. Guide students to include dimensions in their sketches.
- Guide students to present their ideas and their claims for why the idea may successfully solve the problem and how this structure works with the other body structures in a system to support animal survival with their partner. Encourage students 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.

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

- Introduce a decision matrix as a way to decide on the best solution. 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 design.
- Explain to students what they will build their models on and how they will test them.
- Remind students to revisit the criteria so their model contains all elements.
- Direct students to the materials available. Guide pairs to use the best solution to build their model of the prosthesis with the available materials.
- To facilitate creation of the prostheses, circle around the room and assess student progress. Ask students to share their ideas and their thinking with you as they work.

> **Note**: As students work, this is a good time to apply mathematical skills, such as use appropriate tools strategically, model with mathematics, and attend to precision. For example, students will need to use appropriate tools to measure the animal models to fit their designs, record measurements of the model, being careful to use precise measurements and appropriate units when planning and building their prosthesis.

- Guide students to add a drawing or a photograph of their model in the corresponding section of their Launch Log.
- 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.

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

- Direct students to share their prototypes with the class. Each student pair should present their prototype, demonstrating how it fits.
- Place students in small groups. Groups should include four pairs—one for each animal presented in the original design problem.
  - The group should discuss each model and evaluate whether or not it meets each of the design criteria, offering feedback on each.
- Guide students to reflect on the strengths and weaknesses of their model. Have them consider:
  - How does the prototype meet the needs of your animal?
  - What can you do to improve your design?
- After students identify the strengths and weaknesses of their design, have them make improvements to the prototype 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.

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

- Guide students to create a digital presentation.
- The digital product should include:
  - How the design addresses each problem criteria
  - Research examples
  - Sketches, images, or video of the model
  - Images or video of how it fits
- Provide time for students to share their digital presentations.
- After all presentations, lead a discussion about the features, strengths, and weaknesses of the different prototypes.

  - In what ways did your design meet the needs of your injured animal?
  - How was your design similar to the designs of students that chose the same animal? Which design was the most effective for your animal?
  - If you could improve anything about your design, what would you improve? Why would you improve that aspect?
  - ¿Cómo has contribuido al éxito del diseño de tu equipo?
  - ¿Cómo han contribuido los integrantes de tu equipo al éxito del diseño?

- Guide students to complete the Explain section of their Launch Logs. Have students provide suggestions for improvement to their design 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.

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

18 Direct students to complete the Organisms: Structure and Function 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 your knowledge of animal structures and systems prepare you to create a prosthesis for an injured animal? Provide specific examples of what you have learned and how it can be seen in your design.

Student responses will vary.

2 If you could help any injured animal by designing a prosthesis, what animal would it be and what structure would you create? Describe how your prosthesis is important to the survival of the animal.

Student responses will vary.

Introduction to the Module

Waves and the Properties of Light

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: Waves and the Properties of Light Teacher Guide**.

PREFACE

Time: 10 instructional hours

In this module, students learn about waves. Students observe the amplitude and wavelength of waves in a simulation, and describe their patterns. They learn that waves move energy from one place to another, which can cause objects to move.

After students establish an understanding of waves and their patterns, they take a look at light waves. They learn that colors are determined by their wavelengths as they complete a color investigation using the primary colors of light.

Then, students explore properties of light, including reflection, refraction, and how light interacts with different materials that are transparent, translucent, and opaque. They use the design process to design a game that incorporates their knowledge and skills about light gained throughout the module.

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 Consider the relationship between patterns and natural phenomena.

ESSENTIAL QUESTIONS

EQ

EQ1 How are waves used to predict results and solve problems?
EQ2 How do the properties of light allow us to see?
EQ3 How can we use patterns to make sense of the world?
EQ4 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 Waves are moving disturbances that transfer energy between objects.
U3 Light is the form of energy that makes it possible to see things. It travels in waves that allow objects to be seen if they reflect available light or they give off their own light.
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 make sense of phenomena and solve problems.
- LO2 Develop a model to describe patterns of waves.
- LO3 Develop a model of the interaction between light and matter.
- LO4.1 Apply mathematical thinking to solve problems.
- LO4.2 Apply geometry 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 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 Describe the wavelength and amplitude of waves.
- KS2.2 Identify how waves travel from one place to another.
- KS2.3 Describe how waves can cause objects to move.
- KS2.4 Describe cause and effect relationships with waves.
- KS3.1 Identify unique properties of light.
- KS3.2 Identify that light is a form of energy that travels freely through space.
- KS3.3 Describe that when light bounces back from an object, it is called reflected light.
- KS3.4 Describe how we are able to see objects because light is reflected.
- KS3.5 Describe the movement of light as it passes through different substances as transparent, translucent, or opaque.
- KS3.6 Describe how we are able to see colors due to their wavelength.
- KS4.1.1 Reason abstractly and quantitatively. [CCSS.MATH.PRACTICE.MP2]
- KS4.1.2 Model with mathematics. [CCSS.MATH.PRACTICE.MP4]
- KS4.1.3 Use appropriate tools strategically. [CCSS.MATH.PRACTICE.MP5]
- KS4.2.1 Draw points, lines, line segments, rays, angles (right, acute, obtuse), and perpendicular and parallel lines. Identify these in two-dimensional figures. [CCSS.MATH.4.G.A.1]
- KS4.2.2 Recognize angles as geometric shapes that are formed wherever two rays share a common endpoint, and understand concepts of angle measurement. [CCSS.MATH.MD.C.5]
- KS4.2.3 Measure angles in whole-number degrees using a protractor. Sketch angles of specified measure. [CCSS.MATH.4.MD.C.6]
- 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.
- KS7.1 Engage in and maintain positive interactions and relationships with other children and adults.

RESOURCES

R

- Curriculum Framework
- Connections to Standards
- Fourth Grade Connections to Standards
- Family Letter
- Additional Instructional Resources
- Fourth 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 Waves and the Properties of Light 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 **Waves and the Properties of Light Module-specific PD Resources** to review:
  - Waves and the Properties of Light APB Overview
  - Waves and the Properties of Light 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**:

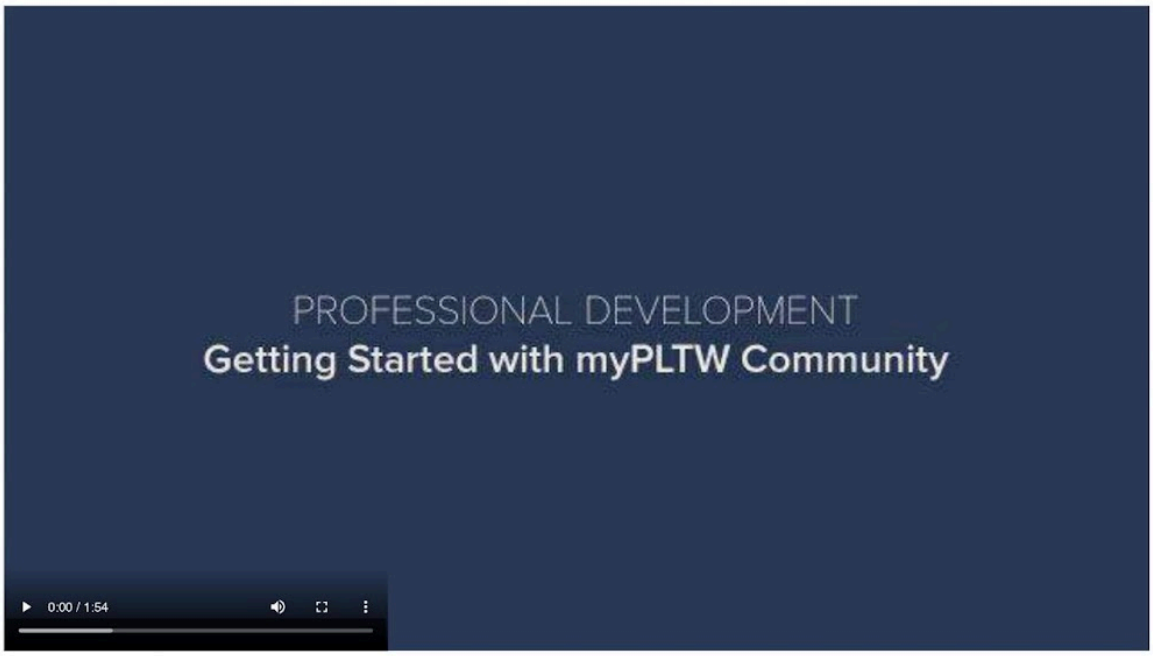
- The Art of Questioning

- 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, these discussion groups are a great way to connect with the PLTW Launch network.



Getting Started with myPLTW Community

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 Waves and the Properties of Light module. To encourage career connections in the classroom, you could invite speakers, such as light designers, stage hands, seismologists, electronic engineers, or ultrasound or x-ray technicians, to talk about light and waves.

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 **Fourth Grade Curriculum Revisions**.

Introduction Story

Mirror Maze

Teacher Resources

View Student Course

RESOURCE

R

Introduction Story: Mirror Maze

Time: 20 Minutes

Introduction

To set the stage for learning, guide students to read the Introduction Story: *Mirror Maze*, a fictional story that introduces the problem. You can 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: *Mirror Maze*. 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 is 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

What Are Waves?

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
• Metal coil spring	• PLTW Launch Logs (1 per student) • Digital devices • Pencils or colored pencils for sketching • Chart paper • Markers	• Inkling • ShowMe Interactive Whiteboard • PhET® Wave on a String simulation

RESOURCE

R

Grades 3–5 Launch Log

ESSENTIAL QUESTIONS

EQ

EQ1 How are waves used to predict results and solve problems?
EQ2 How do the properties of light allow us to see?
EQ3 How can we use patterns to make sense of the world?
EQ4 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 Develop a model to describe patterns of waves.
LO4.1 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

KS1.2.3 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 Describe the wavelength and amplitude of waves.
KS2.2 Identify how waves travel from one place to another.
KS2.4 Describe cause and effect relationships with waves.
KS4.1.1 Reason abstractly and quantitatively. [CCSS.MATH.PRACTICE.MP2]
KS4.1.2 Model with mathematics. [CCSS.MATH.PRACTICE.MP4]
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.
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 **Waves and the Properties of Light Module-specific PD Resources** to review:

- Building Your Understanding: Observing and Describing Waves
- Building Your Understanding: Computer Models and Simulations

Part 1. Waves and Their Properties

1. Before you begin Activity 1, read the **Introduction Story: *Mirror Maze*** with students.
2. Use a piece of chart paper to prepare a KWL chart titled "Waves" for the class.
3. Another option is to create the chart using the ShowMe Interactive Whiteboard app and project the chart for students to view.

Waves		
K	W	L
What do you know?	What do you want to learn?	What did you learn?

4. View the Waves Demonstration video to observe how to accurately move the metal coil spring before doing this with students.



Waves Demonstration video

Part 2. Doing the Wave

This part of the activity calls for students to work in an open space. Consider moving some of the desks or tables to the perimeter of the room so that you have an open space for students to move around. Or you can use an existing open space, such as a lobby, gymnasium, or cafeteria.

Part 3. Waves Simulation

Test the link to the **PhET Wave on a String simulation** before you present it to students.

The *Wave on a String* simulation allows students to create their own waves and explore wave concepts, such as amplitude, frequency, damping, tension, speed, reflection, and interference.

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, explore the different features available in the simulation on your own for 5–10 minutes. Then, use the following steps to explore amplitude and wavelength.

- Set the simulation to the Oscillate setting, with No End, and set Damping to None.
  - Predict what will happen when you change the amplitude.
  - Adjust the amplitude. The height of the wave increases as you increase the amplitude, and vice versa.
  - Set the Amplitude to 1.00 cm. Pause the simulation and use the Rulers feature to measure the Amplitude. You should see that the Amplitude is equal to 1.00 cm.
  - Predict what will happen when you change the frequency.
  - Adjust the Frequency. You should see the Wavelength increase as you decrease the Frequency, and vice versa.
  - Set the Frequency to 2.00 Hz. Pause the simulation and use the Rulers feature to measure the Wavelength. It should equal about 3.10 cm.
- Set the simulation to the Pulse setting, with a Fixed End, and set Damping to None.
  - To start the wave, select the green button.
  - The wave starts on the left-hand side above the dotted line, and reflects below the dotted line.

Time: 110 Minutes

Introduction

In this activity, students are introduced to *waves*. They learn how waves travel and they identify their *patterns*. Through a simulation, students explore *amplitude* and *wavelength*, as well as how waves *reflect*.

amplitude	The height of a wave from rest to crest, or from rest to trough.
crest	The highest point of a wave.
energy	The ability to do work. Waves carry energy from one location to another.
frequency	The number of times something repeats within a fixed period, such as number of cycles per second.
pattern	Something that is repeated over and over.
reflection	The return of waves from a surface.
trough	The lowest point of a wave.
wave	A disturbance that travels through space or matter, transferring energy from one place to another.
wavelength	The distance between two corresponding points on a wave.

Possible Student Misconception

A wave pulse travels faster on a string if I move the string up and down more vigorously. Flicking a string harder increases the amplitude of the pulse, but it does not make the pulse travel faster.

Procedure

Part 1. Waves and Their Properties

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. Direct students to access the flashcard example as you introduce the vocabulary term *wave*.
5. Introduce the students to a KWL graphic organizer. This graphic organizer will be used to record what the students already know about waves, what they hope to learn, and what they learn from this module. Use the KWL graphic organizer to identify misconceptions students have about waves.

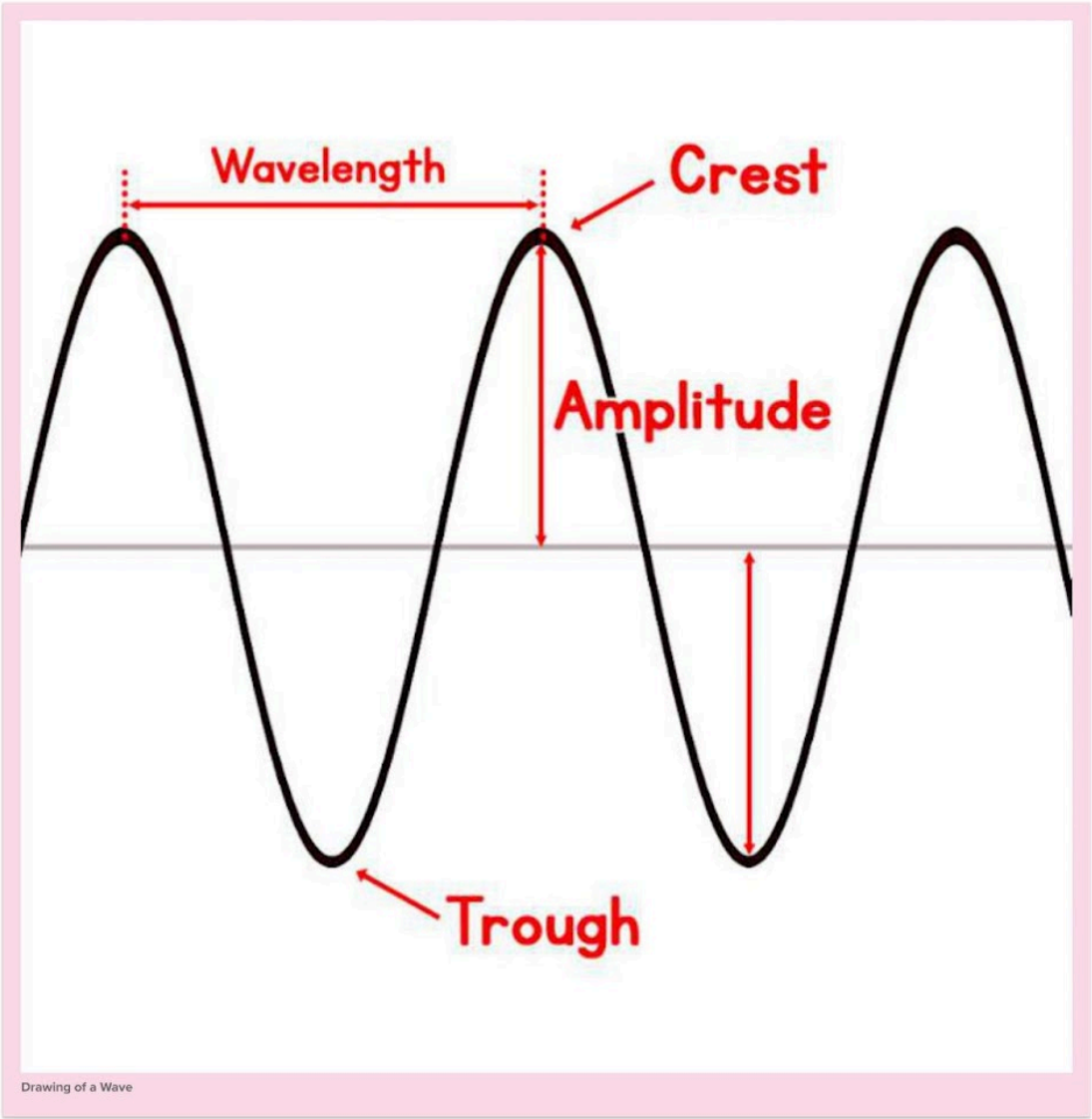
6. Guide students to create a KWL chart in their Launch Logs.
7. Have students work individually, with a partner, or in a small group. Have students complete the first two columns in the KWL chart to record their responses about waves. All students, whether working individually or with a partner or group, should create the chart and record the responses in their own Launch Logs.
8. Monitor student groups as they fill out the KWL chart, to gauge their understanding of the concepts. Allow time for groups to share their responses in the first two columns.
9. Record the student responses in the class KWL chart.
10. Use the metal coil spring to observe one type of wave.
    - Hold one end of the spring on one side of a table.
    - Have a student volunteer hold the other end of the spring and stretch it across the table.
    - Holding the other end, quickly push the end of the coil to show the pulse moving from one end of the coil to the other. This demonstrates reflection. Direct students to access the flashcard example as you introduce the vocabulary term *reflection*.
    - Direct students to observe the patterns they see in the wave. Direct students to access the flashcard example as you introduce the vocabulary term *pattern*.
11. Direct students to view the video about Waves in water in the student course. Guide students to observe the patterns they see in the waves of the water.
12. Lead a discussion about the patterns students noticed on the waves in the metal coil spring and in water.

    - What similarities did you notice between the two different waves? Use evidence to explain the phenomena.
    - What differences did you notice between the two different waves? Use evidence to explain the phenomena.
    - Can you identify reflection patterns in the two different waves? If so, what patterns did you see?
    - Now that you have seen these examples of waves, identify examples of waves in the real world.

13. Introduce wave properties to students. Direct students to access the flashcard examples as you introduce the vocabulary terms *amplitude*, *wavelength*, *crest*, and *trough*.
14. Have students reflect on amplitude and wavelength.

    - In your own words, what is amplitude? Why do you describe it this way?
    - In your own words, what is wavelength? Why do you describe it this way?

15. Have students draw a wave and label the parts in their Launch Logs.



Drawing of a Wave

Part 2. Doing the Wave

16 Lead a discussion to introduce frequency to students.

- What is something you do frequently? How often do you do it?
- What is something you do rarely? How often do you do it?

17 Tell students that waves can happen frequently or rarely. Direct students to access the flashcard example as you introduce the vocabulary term *frequency*.

18 Tell students they are going to do the wave to practice some of the properties they have learned.

19 Guide students to stand in a circle, shoulder to shoulder, facing into the circle.

20 Select a student to begin the wave. When you say "Go," the first student raises a hand, which prompts the neighboring student to raise a hand, and so on, creating a wave. Allow the wave to travel around the circle several times for each round.

- **Round 1**: Low frequency - Students move the wave around the circle slowly.
- **Round 2**: High frequency - Students move the wave around the circle quickly.
- **Round 3**: Low amplitude - Students raise their arms only slightly, at any frequency. The student who starts the wave dictates the height.
- **Round 4**: High amplitude - Students raise their arms as high as they can, at any frequency.
- **Round 5**: Low wavelength - Students move the wave around the circle at any frequency while standing shoulder to shoulder.

- **Round 6**: High wavelength - Students step back from each other so they are no longer standing shoulder to shoulder. Students move the wave around the circle at any frequency while standing further apart.

21 Lead a discussion about the different waves.

- How does frequency affect the motion of the wave? What patterns did you observe?
- How does amplitude affect the motion of the wave? What patterns did you observe?
- How does wavelength affect the motion of the wave? What patterns did you observe?

22 Guide students to draw the different types of waves they observed in their Launch Logs. If students need assistance in their sketches, direct them to review the vocabulary flashcards.

Part 3. Waves Simulation

23 Direct students to the **PhET Wave on a String** simulation and give an introduction of the simulation to the class. Students can find the link in the Equipment table or Procedure.

24 Allow time for students to explore with a partner or small group the features available in the simulation.

25 Guide students to follow the instructions in the student course as they explore amplitude and wavelength in the simulation. Students should explore the simulation and identify patterns they observe in regard to amplitude and wavelength.

26 Direct students to record their observations in their Launch Logs.

27 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.

28 Use the Wave on a String simulation and a sample claim to model for students how to support the claim with evidence.

- Project the simulation to the whole group.
- Set the simulation to the Oscillate setting, with No End, and set Damping to None.
- Introduce the sample claim: The wavelength of a wave is the same when measured between **any** two similar points on the wave.
- Ask students how they think they can use the simulation to provide evidence for this claim.

Sample Evidence: Use the ruler to measure the wavelength at multiple points on the wave.

29 Direct students to read the claims in the student course with a partner or small group.

30 Guide students to:

- Use the Wave on a String simulation to support each claim about waves with evidence.
- Record their observations in their Launch Logs using descriptions, sketches, notes, and measurements.
- Label their claim statements and their evidence statements.
- Add what they learned, including the claims that are supported by evidence, to the "L" column of their KWL charts.

Student responses should demonstrate an understanding of amplitude and wavelength. Responses might include:

- Evidence 1: I used the ruler feature to measure the amplitude from the center line to the top of the peak, and the center line to the bottom of the trough. They were both equal to 1 cm.
- Evidence 2: In the simulation, I set the amplitude to 1 cm, and set the frequency at 2.50 Hz. At this amplitude, the wavelength was equal to about 2.5 cm. I changed the amplitude to 0.50 cm, and the wavelength was still equal to 2.5 cm.
- Evidence 3: When the frequency was set to 2.00 Hz, the wavelength was a little greater than 3 cm. When I increased the frequency to 3.00 Hz, the wavelength decreased to a little greater than 2 cm.
- Evidence 4: I started the simulation with the amplitude set at 1.00 cm and frequency at 1.00 Hz. When I increased the frequency to 2.00 Hz, the amplitude stayed the same at 1.00 cm.
- Evidence 5: When the simulation was set with a fixed end, the incoming wave and the reflected, outgoing wave showed that the peak of the wave turned into the trough.

18 Lead a discussion about the claims and evidence statements. As students share their answers, record them on the KWL chart in the "L" column.

- What patterns did you notice in terms of amplitude and wavelength for each claim?
- What evidence do you have for your thinking?

19 Reflect on this activity. Guide students to use the KWL chart in their Launch Logs to record their reflections.

- What surprised you as you learned about waves?
- What did you learn about patterns in waves?
- What new questions do you have, that you want to learn more about?

20 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 one pattern of a wave using the terms amplitude and/or wavelength. Support the pattern with evidence from the activity.

Student responses should demonstrate an understanding of wave patterns. Responses might include:
One pattern is that the amplitude of a wave is the same whether you measure it from the center line to the peak, or the center line to the trough. I noticed this in the simulations when I used the ruler to measure.

2 Using your knowledge from the simulation, describe how frequency and wavelength are related. Why do you think when one changes, the other one changes as well? Use evidence to support your answer.

Student responses should demonstrate an understanding of frequency and wavelength. Responses might include:
When doing the simulation, if I increased the frequency so that the string moved up and down more quickly, the wavelength was shorter. Or if I decreased the frequency so that the string moved up and down more slowly, the wavelength was longer. Frequency means how quickly something happens, so if the wave is moving quicker, that means the wavelength has to be shorter to accommodate, and vice versa.

Activity 2

The Motion of Waves

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
• Speaker (1 per group) • Plastic cup (1 per group) • Cling wrap • Rubber bands (1 per group)	• PLTW Launch Logs (1 per student) • Digital devices • Pencils or colored pencils for sketching • Salt, rice, sand, or sugar (1 pinch per group) • Scissors	• Inkling • PhET® Waves Intro simulation

ESSENTIAL QUESTIONS

EQ

EQ1 How are waves used to predict results and solve problems?
EQ2 How do the properties of light allow us to see?
EQ3 How can we use patterns to make sense of the world?
EQ4 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 Develop a model to describe patterns of waves.
LO6 Communicate effectively for specific purposes and settings.
LO7 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 Identify how waves travel from one place to another.
KS2.3 Describe how waves can cause objects to move.
KS2.4 Describe cause and effect relationships with waves.
KS6.1 Document work in an organized notebook.
KS7.1 Engage in and maintain positive interactions and relationships with other children and adults.

Preparation

Professional Development

Before you facilitate Activity 2, access the **Waves and the Properties of Light Module-specific PD Resources** to review:

- Building Your Understanding: Sound—A Deeper Background
- Building Your Understanding: How We Hear Sound

Activity 2

1. Gather the materials for the model eardrum. Each group needs:
   - Plastic cup
   - 12 inches of cling wrap
   - Rubber band
   - Salt, rice, sand, or sugar (1 pinch)
   - Speaker
   - Digital device

   Decide whether students will gather the materials for making the device from a central location or you will prepare the materials for each group.
2. Become familiar with the materials and device setup for the model eardrum. This device demonstrates that energy from sound waves makes a membrane vibrate. This helps make sound waves visible for students. For more information, see the Model Eardrum Setup presentation in the student course.

   > **Note**: In the setup of the model eardrum, students are directed to cut the bottoms off the plastic cups. Alternatively, you can cut the bottoms off the cups before beginning this activity.

3. Test the link to the **PhET Waves Intro** simulation before you present it to students.

   > The *Waves Intro* simulation allows students to use a speaker to create a sound wave. They observe the sound wave as particles, waves, or both.
   >
   > 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.

4. To become familiar with the simulation, complete the following steps.
   - Select Sound from the Waves Intro page.
   - To visualize both the sound waves and the movement of the air particles, select Both. Students will use the Waves, Particles, and Both settings while using the simulation.

     > **Note**: The wavelength, frequency, and size of the air particles are not to scale. Notice the key in the upper-left corner, which shows the length of 50 cm. Students can take other measurements with the tools provided, as needed.

   - If your digital device has a speaker or is connected to a wireless speaker, when you select Play Tone, you will hear the tone.
   - Observe that while the wave travels out from the speaker, the air particles oscillate side to side around the same point.
5. For more information about how to use the model eardrum and simulation, review **DL: Activity 2: The Motion of Waves**. This procedure in student distance learning provides videos and images that can help students complete this activity.

Time: 60 Minutes

Introduction

In this activity, students observe how a disturbance that travels through a *medium* causes a *wave*. They learn that the particles or small parts of the medium move in place up and down, or side to side, while the *energy* travels through the medium from one location to another.

amplitude	The height of a wave from rest to crest, or from rest to trough.
energy	The ability to do work. Waves carry energy from one location to another.
frequency	The number of times something repeats within a fixed period, such as number of cycles per second.
medium	Any substance that waves move through.
wavelength	The distance between two corresponding points on a wave.

Possible Student Misconceptions

- **As a wave moves through a medium, the medium travels with the wave.** The disturbance causes the matter in the medium to oscillate. The energy moves through the medium, but the matter vibrates or oscillates in place.
- **Sound can move through empty space.** Sound needs a medium to move through. The medium is often air, which we cannot see, but without air or another medium, sound waves would not be able to travel. Only light waves can move through empty space.

Procedure

1. Lead a discussion to review Activity 1.

   - What are some phenomena that travel in waves? Direct students to access the flashcard example to review the vocabulary term *wave*.
   - How would you describe the patterns of wavelength and amplitude in waves? Direct students to access the flashcard examples to review the vocabulary terms *wavelength* and *amplitude*.
   - How does frequency affect the motion of waves? Direct students to access the flashcard example to review the vocabulary term *frequency*.

2. Direct students to access Activity 2 in the student course and have them read the Introduction.
3. Have students prepare their PLTW Launch Logs for Activity 2.
4. If your students have participated in the PLTW Light and Sound module, they have observed a tuning fork that caused the surface of water in a container to move and splash. Remind students of this experience. If you have a tuning fork available, demonstrate how the vibrations of the fork cause the surface of the water to move.
5. Introduce that in this activity, students will use a model to make sound waves visible. Share with students that the model represents an eardrum. The energy from the sound wave makes the membrane, or cling wrap, vibrate.
6. Optional: Demonstrate the setup to the students.
7. Guide students to construct the device, following the instructions in the Model Eardrum Setup presentation in the student course.
8. Guide student groups to plug their speaker into their digital device.
9. Introduce the **PhET Waves Intro** simulation. Lead a discussion about aspects of the simulation.

   - How can the wavelength be changed?

     Changing the frequency changes the wavelength, because the two are related.

   - Does changing the frequency and wavelength change the amplitude?
   - Does changing the amplitude change the frequency and wavelength?

10. Direct the students to access the simulation and guide them to use the procedure in the student course to observe the movement of the salt, rice, sand, or sugar as they play different tones.
11. Optional: Demonstrate to the whole class how salt moves when the speaker plays music compared to a pure tone.
12. Guide students to record their observations in their Launch Logs. Observations should include a sketch of the motion of the salt, rice, sand, or sugar on the cling wrap for:
    - At least two different tones at the same volume
    - At least two different volumes of the same tone

    The tone changes the frequency or wavelength of the wave. The volume changes the amplitude or the energy of the wave.

13. Lead a discussion about their observations.

- In the simulation, sound travels through air, which is a medium. How do you think the sound wave travels from the speaker to the plastic wrap through the air? Direct students to access the flashcard example as you introduce the vocabulary term *medium*.

  The simulation makes invisible processes, such as sound waves spreading out and air particles vibrating, visible for students. Collisions between air particles pass the energy of the sound wave from particles to particles and allow the sound to spread out. The air particles themselves move back and forth, or vibrate, in place. The air particles do not move from the speaker to the membrane.

- Describe the process of the energy of the sound wave traveling outward from the speaker. Direct students to access the flashcard example as you introduce the vocabulary term *energy*.

  The sound wave travels as air particles collide with one another. Air particles move back and forth but stay in place; due to their collisions, the energy of the wave spreads out.

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

Conclusion Questions Answer Key

1 Based on your observations, describe how your eardrum hears sounds.

Student responses should demonstrate an understanding of vibration. Responses might include:
Sound waves travel through different mediums, like air. Then, the waves vibrate our eardrums, which allows us to hear the sounds.

2 If there were no air particles, such as in outer space, would sound waves be able to travel?

Student responses should demonstrate an understanding of how sound waves travel. Responses might include:
Without air particles, or some other medium, sound could not travel because the motion of the wave depends on collisions.

Activity 3

Light Waves

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
• *Light and Its Effects* by Jenna Winterberg • Small mirror • Flashlights (3 per group) • Color filter cards (1 set per group)	• PLTW Launch Logs (1 per student) • Digital devices • Pencils or colored pencils for sketching • Chart paper • Markers • Container, such as a shallow baking dish • Water	• Inkling

ESSENTIAL QUESTIONS

EQ

EQ1 How are waves used to predict results and solve problems?
EQ2 How do the properties of light allow us to see?
EQ3 How can we use patterns to make sense of the world?
EQ4 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 Develop a model to describe patterns of waves.
LO3 Develop a model of the interaction between light and matter.
LO5 Collaborate effectively on a diverse and multidisciplinary team.
LO6 Communicate effectively for specific purposes and settings.
LO7 Practice ethical behavior in all settings.

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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.
KS1.2.5	Analyze models as an explanation of phenomena.
KS2.1	Describe the wavelength and amplitude of waves.
KS2.2	Identify how waves travel from one place to another.
KS3.1	Identify unique properties of light.
KS3.2	Identify that light is a form of energy that travels freely through space.
KS3.3	Describe that when light bounces back from an object, it is called reflected light.
KS3.4	Describe how we are able to see objects because light is reflected.
KS3.6	Describe how we are able to see colors due to their wavelength.
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.
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 **Waves and the Properties of Light Module-specific PD Resources** to review:

- Building Your Understanding: Light Waves
- Building Your Understanding: How Light Waves Travel
- Building Your Understanding: How We See

Part 1. Introduction to Light

Sensitively Addressing Color Blindness in Your Class

Activity 3: Light Waves introduces light to students. The focus of this activity is on the visible spectrum and how the colors of light interact. As you progress through this module, be sensitive to students who have color blindness. The most common type of color blindness makes it hard to tell the difference between red and green. Another type makes it hard to tell the difference between blue and yellow. The last type is complete color blindness.

If you have a student with color blindness, it can be helpful to:

- Use white chalk or a black marker when writing on the board.
- Label materials with the name of the color, such as the color filter cards in this activity.
- Always use white paper.
- Pair students with others who do not have color blindness.

1. Use a piece of chart paper to prepare a KWL chart titled "Light".

Light		
K	W	L
What do you know?	What do you want to learn?	What did you learn?

2. Read *Light and Its Effects* to become familiar with the book, prior to reading it to students.
3. Fill a container, such as a shallow baking dish, with water. Have the small mirror ready to use with the filled container. Follow step 10 in the procedure to test out the Indoor Rainbow Simulation before completing the demonstration with students.

Part 2. Color Investigation

1. Place flashlights and color filter cards on a table for students to use while competing the color investigation. If you do not have a designated supply table, you may divide up the materials to place them at each table.
2. Darken the classroom by pulling down blinds or covering the windows with blankets. If the room is not dark enough, find a dark room in the school to complete the investigation.

Time: 110 Minutes

Introduction

In this activity, students activate their prior knowledge of *light* by considering how light helps them see in their daily lives. They are introduced to the *electromagnetic spectrum*, focusing on the visible light we see everyday. Students explore how light travels in *waves*, and how *wavelength* determines color. Students complete a color investigation using the *scientific inquiry process* to predict what happens when you mix the primary colors of light.

electromagnetic radiation	A form of energy that is all around us, including radio waves, visible light, and X-rays.
electromagnetic spectrum	The range of electromagnetic radiation that is all around us, such as radio waves, visible light, and X-rays.
energy	The ability to do work. Waves carry energy from one location to another.
light	The form of energy or electromagnetic radiation that makes it possible to see things.
reflection	The return of waves from a surface.
scientific inquiry process	A process that scientists use to explore observations and answer questions.
visible spectrum	The part of the electromagnetic spectrum that people can see. It contains red, orange, yellow, green, blue, indigo, and violet light.
wave	A disturbance that travels through space or matter, transferring energy from one place to another.
wavelength	The distance between two corresponding points on a wave.

Possible Student Misconceptions

- **White light is colorless**. White light seems colorless, but it actually contains a spectrum of colors including red, orange, yellow, green, blue, indigo, and violet. White light bounces off objects and reflects only some of the waves. For example, when white light strikes an apple, only the red waves are reflected, so the apple appears red.
- **The color of an object is fixed**. The color of an object depends on the light used to illuminate it, the object's absorption and reflection of light, and the eye of the viewer. A green object illuminated with a yellow light appears dark.
- **We see things because light travels from our eyes toward an object**. Light travels in waves from a light source, such as the sun. The light waves reflect, or bounce off everything around us, and enter our eyes.
- **Only shiny objects reflect light**. All objects reflect and absorb light to some extent.
- **Objects either reflect or absorb light, and cannot do both at the same time**. All objects reflect and absorb light to some extent. White objects reflect more light than they absorb, while black objects reflect less light and absorb more.

Procedure

Part 1. Introduction to Light

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. Direct students to view the Aurora Borealis video in the student course. Lead a discussion about the video.

   - What patterns do you notice about the lights?
   - What patterns do you notice in the waves?
   - What colors do you see? What do you think causes us to see these different colors?

4. Direct students to access the flashcard example as you introduce the vocabulary term *light*.
5. Guide students to create a KWL chart in their Launch Logs.
6. Have students work individually, with a partner, or in a small group. Have students complete the first two columns in the KWL chart to record their responses about waves. All students, whether working individually or with a partner or group, should create the chart and record the responses in their own Launch Logs.
7. Monitor student groups as they fill out the KWL chart to gauge their understanding of the concepts. Allow time for groups to share their responses in the first two columns.
8. Record the student responses in the class KWL chart.
9. Direct students to access the flashcard examples as you review the vocabulary terms *energy*, *wave*, and *wavelength*.
10. Read aloud pages 4–11 of the book *Light and its Effects*. You may choose to use a document viewer to project an image of the book.
    - When you get to page 7, complete the "Indoor Rainbow" simulation as a whole class.

> **Note**: If it is an overcast day, you can complete this simulation with a flashlight. Turn off the lights, place the small mirror into the water at an angle facing upward, and shine a flashlight onto the part of the mirror that is in the water.

- Direct students to access the flashcard examples as you introduce the vocabulary terms *electromagnetic radiation*, *electromagnetic spectrum*, and *visible spectrum*.
- Guide students to complete a Think-Pair-Share about their prediction of what will happen when white light reflects off of a mirror that is placed in water.
- Take your prepared container filled with water, and place it near a sunlit window.
- Place the small mirror in the water, and angle it toward the light.
- A rainbow appears on the wall.
- Lead a discussion about what is occurring in the simulation.

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.

- Were your predictions correct? Use evidence to explain.
- Why did the colors of the rainbow appear?

While light seems colorless, it contains a spectrum of colors including red, orange, yellow, green, blue, indigo, and violet.

- When you get to page 10, direct students to access the flashcard example as you review the vocabulary term *reflection*.

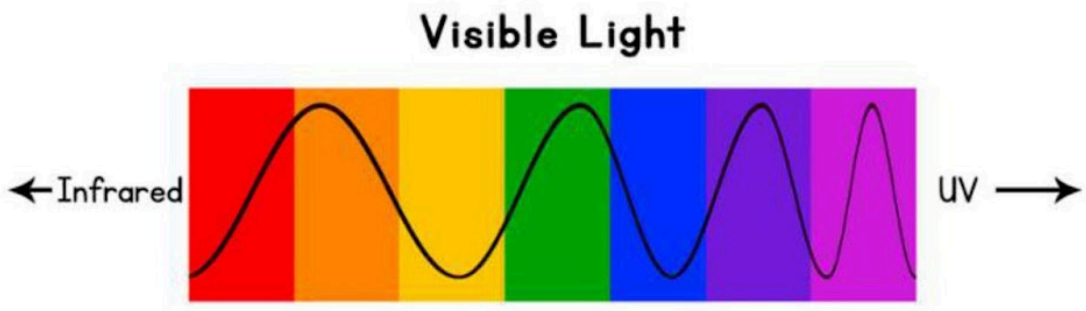
11 Lead a discussion about the first part of the book that focuses on electromagnetic spectrum and color.

- We learned that wavelength determines what color we see objects as, with red having the longest wavelength and violet the shortest. What do you think amplitude determines? Why do you think this? Direct students to access the flashcard example as you review the vocabulary term *amplitude*.

Amplitude determines the intensity, or brightness of light. It is a measure of how much energy the wave has.

- What are different sources of light?

12 Direct students to draw the visible spectrum in their Launch Logs. They should add the colors in order and draw a wave, with the wavelength getting shorter as it reaches violet. Have students describe how wavelength determines the color we see, as light is reflected off of an object.



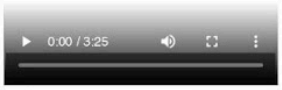
Visible light spectrum

Part 2. Color Investigation

13 Ask students what they think scientists do. Discuss with students 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 light waves.

14 Explain to students that they are going to use the same process scientists use when asking questions about the world around them. Use the flashcard example to introduce the vocabulary term *scientific inquiry process*.

15 Present 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?
- 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 Introduce the color investigation to students. Students experienced similar concepts if they participated in the PLTW Light and Sound module, but this goes deeper into the wavelengths of light and how we see.

Human eyes can only detect certain wavelengths, so visible light is the only kind of electromagnetic radiation we can see. The three primary colors of light are red, green, and blue. Students will investigate what happens when you mix these three colors of light.

18 **Ask**: Lead a discussion about what students are interested in regarding colors of light.

- Have you ever wondered what happens when different colors of light are mixed? What do you wonder?
- What do you think happens when red, green, and blue light is mixed? Why do you think this?

Introduce the testable question for this investigation: What happens when you mix red, blue, and green colored light in different combinations?

19 **Predict**: Guide students to make a prediction to answer the testable question for this investigation.

- Lead a discussion on the testable question.

  What happens when you mix red, blue, and green colored light in different combinations? Why do you think this?

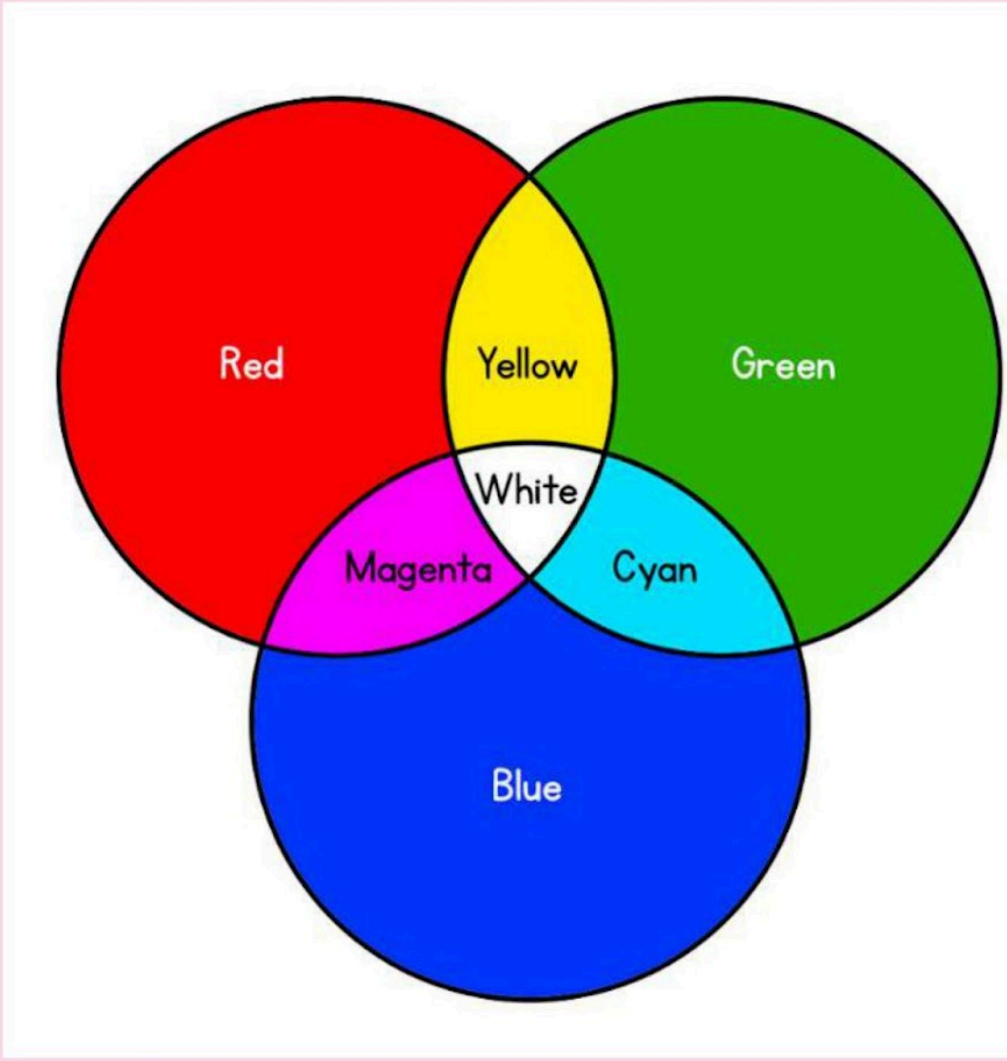
- In small groups, direct students to determine the possible color combinations among red, blue, and green. Guide them to make a prediction of the resulting color of light for each combination. Have students record their predictions in their Launch Logs.

Color Investigation		
Combination	Prediction	Result
Red/Green		
Red/Blue		
Green/Blue		
Red/Blue/Green		

20 **Investigate**: Turn off the lights in the classroom. Guide each group to test the different color combinations of light using flashlights and color filter cards.

21 **Observe**: Guide students to observe the resulting color when they combine red, green, and blue light. Then, have students use their Launch Logs to draw a three-circle Venn Diagram to indicate the mixing of colored light.

Color Investigation		
Combination	Prediction	Result
Red/Green		Yellow
Red/Blue		Magenta
Green/Blue		Cyan
Red/Blue/Green		White



Mixing colored light Venn diagram

22 **Explain**: Lead a discussion about what students observed during the investigation. Ask students to explain their thinking as they share their thoughts. Be sure to address misconceptions.

- Think about the resulting color for your combinations of light. Which of your predictions were correct? Which were not correct?
- Choose an object from your daily life. Explain which light waves may be reflecting off that object to allow us to see it as the color it is.

> Light reflects off of objects and enters our eyes, which allows us to see them. Because a pumpkin is orange, that means that orange light waves are reflecting off the pumpkin and entering our eyes.

- How do your results differ from what you would see if you mixed paint pigments, rather than light? Why do you think this is?

> **Note**: Mixing the primary colors of light, red, blue, and green, is known as additive color. Additive color mixing creates a new color when lights of different wavelengths are mixed. As more colors are added, the result becomes lighter, heading toward white. Additive color mixing is easiest to observe in a dark room.
>
> Paint, however, uses a subtractive color method. Subtractive color mixing is creating a new color by the removal of wavelengths. When paint colors mix, wavelengths are deleted from what we see because each paint absorbs some wavelengths that the other paint reflects. As more colors are added, the result becomes darker, heading toward black. Subtractive color mixing is easiest to observe in a bright room.

  - Optional: Provide red, blue, and green paint for students to test the differences in color combinations.
- How are these different color combinations of light used in daily life?

> - Red, blue, and green are all used to create the different colors you see on your computer screen, TV, or any colored electronic display.
> - Light designers use red, green, and blue color gels to mix colored lights together for stage performances.

23 Direct students to record responses in the "W" and "L" columns of the KWL chart in their Launch Logs. Ask students to share their responses and add to the class KWL chart.

- What surprised you as you learned about light?
- What new questions do you have, that you want to learn more about?

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

Conclusion Questions Answer Key

1 Describe patterns of light waves in terms of wavelength. Use evidence from the activity to explain.

> Student responses should demonstrate an understanding of how color is impacted by wavelength. Responses might include:
> White light is a combination of red, orange, yellow, green, blue, indigo, and violet, in that order. The wavelength of red light is longest, and wavelengths get shorter as they reach violet.

2 How do we see the color of objects? Use evidence from the activity to explain.

> Student responses should demonstrate an understanding of reflection. Responses might include:
> We see objects because light is reflected off of the object and into our eyes. To see color, only the color light waves that are reflected are the ones that we see. For example, if I am looking at a shirt that is greenish-blue, or cyan color, then I know that blue and green light waves are reflecting off the shirt. I know this because we learned that blue and green light mixed together make cyan.

Project

Light Exploration

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
• *Light and Its Effects* by Jenna Winterberg • Flashlights (6) • VEX® IQ PLTW Light Game (2 sets)	• PLTW Launch Logs (1 per student) • Digital devices • Pencils or colored pencils for sketching • Chart paper • Markers • Protractors (4) • Boxes or baskets to hold materials (2) • Transparent materials such as: ◦ Glass ◦ Clear plastic • Translucent materials such as: ◦ Frosted plastic ◦ Ice ◦ Tissue paper • Opaque materials such as: ◦ Blocks ◦ Cardboard	• Inkling • PhET® Bending Light simulation

RESOURCE

R

VEX IQ PLTW Light Game Kit Contents

ESSENTIAL QUESTIONS

EQ

EQ1 How are waves used to predict results and solve problems?
EQ2 How do the properties of light allow us to see?
EQ3 How can we use patterns to make sense of the world?
EQ4 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.
LO3 Develop a model of the interaction between light and matter.
LO4.1 Apply mathematical thinking to solve problems.
LO4.2 Apply geometry to solve problems.
LO5 Collaborate effectively on a diverse and multidisciplinary team.
LO7 Practice ethical behavior in all settings.

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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.
KS3.1	Identify unique properties of light.
KS3.3	Describe that when light bounces back from an object, it is called reflected light.
KS3.4	Describe how we are able to see objects because light is reflected.
KS3.5	Describe the movement of light as it passes through different substances as transparent, translucent, or opaque.
KS4.1.1	Reason abstractly and quantitatively. [CCSS.MATH.PRACTICE.MP2]
KS4.1.2	Model with mathematics. [CCSS.MATH.PRACTICE.MP4]
KS4.1.3	Use appropriate tools strategically. [CCSS.MATH.PRACTICE.MP5]
KS4.2.1	Draw points, lines, line segments, rays, angles (right, acute, obtuse), and perpendicular and parallel lines. Identify these in two-dimensional figures. [CCSS.MATH.4.G.A.1]
KS4.2.2	Recognize angles as geometric shapes that are formed wherever two rays share a common endpoint, and understand concepts of angle measurement. [CCSS.MATH.MD.C.5]
KS4.2.3	Measure angles in whole-number degrees using a protractor. Sketch angles of specified measure. [CCSS.MATH.4.MD.C.6]
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.
KS7.1	Engage in and maintain positive interactions and relationships with other children and adults.

Preparation

Professional Development

Before you facilitate the project, access the **Waves and the Properties of Light Module-specific PD Resources** to review Building Your Understanding: Computer Models and Simulations.

Project

1. Before you begin the Project, gather items needed for the centers. The notes for each center prep below include the specific materials you need.

> **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 need.
>
> Guided exploration allows students to build knowledge that contributes to understanding the structure and function of organisms. It is important that each student visit every center to acquire the skills necessary for completing the Problem.

2. Set up each center as follows:
   - **Centers 1 and 4: Reflection**
     - Set up this center to allow students to explore reflection.
     - Review the VEX IQ PLTW Light Game Kit Contents (noted in the Resource section) to understand the pieces included in each set.
     - Prepare one VEX IQ PLTW Light Game set for each center.
       - Remove the transparent, translucent, and opaque pieces for students to use in the Materials Sort center.
       - For the purposes of this center, you can remove two 12 × 12 plates from each set. You will then have two 12 × 12 plates remaining to put at each Reflection center. This allows students to work at this center in groups of two or three.
       - Prepare the mirrors and lasers so they can connect to the 12 × 12 plates. Alternatively, you can have students complete this step while they are at the center.



Centers 1 and 4 Preparation presentation

     - Reserve all remaining pieces from the VEX IQ PLTW Light Game sets and save them to use in the Problem.
     - Place one prepared VEX IQ PLTW Light Game set at each center, as well as two protractors.
     - Materials: PLTW Launch Logs, prepared VEX IQ PLTW Light Game sets, protractors
   - **Centers 2 and 5: Materials Sort**
     - Set up this center to allow students to explore materials and how they interact with light.
     - Collect materials that are transparent, translucent, and opaque. You need at least two materials for each category. Place the materials in two boxes or baskets. Materials can include:
       - Transparent: VEX IQ transparent game pieces, glass cups, glass or plastic ware
       - Translucent: VEX IQ translucent game pieces, frosted plastic, ice, tissue paper
       - Opaque: VEX IQ opaque game pieces, blocks, cardboard
     - Use two pieces of chart paper to prepare two sorting place mats.

Transparent	Translucent	Opaque

     - Place one prepared piece of chart paper, one box or basket full of materials, and three flashlights at each center.
     - Materials: PLTW Launch Logs, prepared pieces of chart paper, boxes or baskets full of materials, flashlights
   - **Centers 3 and 6: Bending Light Simulation**
     - Set up this center to allow students to experience a refraction simulation.
     - Test the link to the **PhET Bending Light** simulation before you present it to students.

> In the *Bending Light* simulation, students can control the wavelength of light and explore how it bends.
>
> For more information about how to use the simulation, create a free account at phet.colorado.edu. You will have access to teacher tips and additional language translations for each simulation.

- To become familiar with the simulation, complete the following steps.
  - Go to the Intro simulation.
  - Within the ray setting, test the following:
    - Adjust the location of the beam. Notice how the location of the ray changes as you move the beam.
    - Drag in the protractor and set it in the middle of the screen, lining it up with where the ray meets the water.
    - The ray above the water is the reflection. What do you notice about the angle measurement of the reflection?
    - The ray below the water is the refraction. What do you notice about the angle measurement of the refraction?
  - Within the wave setting, test the following:
    - Adjust the location of the beam. Notice how the location of the wave changes as you move the beam.
    - Adjust the material of the top and bottom halves. Notice how the location of the wave changes among air, water, and glass.
- Materials: PLTW Launch Logs, digital devices

Time: 90 Minutes

Introduction

In the project, students describe *patterns* of *light* and how light interacts with different materials, which they experience through centers. They explore *reflection* and apply mathematical thinking by measuring the angle of reflection off of mirrors. Then, they identify materials as *transparent*, *translucent*, or *opaque* while making observations. Students complete a simulation to explore how light bends when it interacts with different types of matter.

light	The form of energy or electromagnetic radiation that makes it possible to see things.
opaque	The property of blocking out all light. Light shining on an opaque object creates a shadow.
pattern	Something that is repeated over and over.
reflection	The return of waves from a surface.
refraction	The bending of rays or waves as they pass from one medium to another.
translucent	The property of allowing some light to pass through. You cannot see completely through a translucent object.
transparent	The property of allowing almost all light to pass through. You can see through a transparent object.

Possible Student Misconception

When a light wave moves through a transparent object, the wave moves particles of the object. Light waves transport energy from one place to another. In this process, light waves do not displace the matter they pass through.

Procedure

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. Direct students to access the flashcard examples as you review the vocabulary terms *light* and *pattern*.
4. Read aloud pages 12–27 of the book *Light and Its Effects*. You may choose to use a document viewer to project an image of the book. While on pages 12–13, direct students to access the flashcard examples as you introduce the vocabulary terms *transparent*, *translucent*, and *opaque*.
5. Lead a discussion that focuses on electromagnetic radiation.

- What are some examples of electromagnetic radiation you experience in your daily life? Explain your thinking.

  - Radio waves when listening to music in the car on the way to school
  - X-rays when I broke my wrist and went to the hospital
  - Ultraviolet rays from the sun, so I wear sunscreen to protect myself
  - Microwaves when we heat up food at home

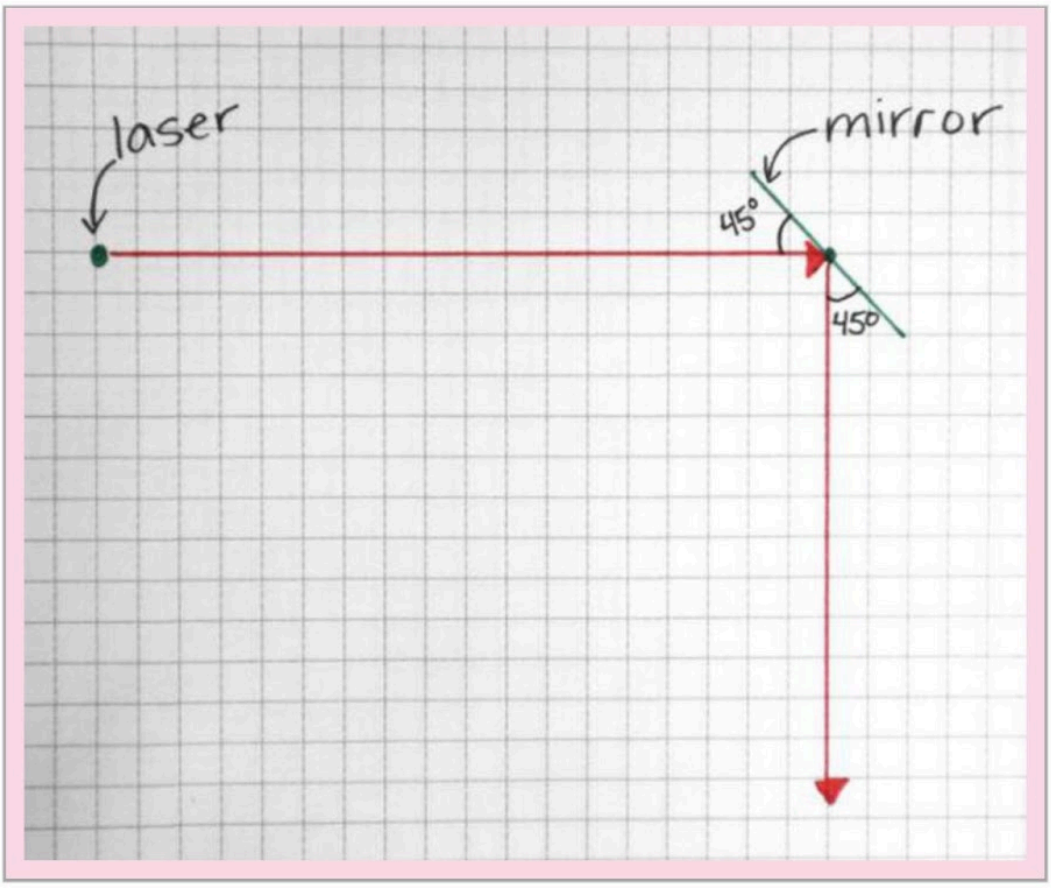
- Can we see all types of electromagnetic radiation? Why or why not?

  No, we cannot. The human eye can only see certain wavelengths. In the electromagnetic spectrum, we call the wavelengths we can see the "visible spectrum". These wavelengths reflect off of objects and enter our eyes.

  The other forms of electromagnetic radiation, such as infrared and ultraviolet, have wavelengths that are either too large or too small for us to see.

6 Introduce each of the following centers to the students in detail. Be sure to present new tools or equipment, such as how to use a protractor at the reflection center.

- **Centers 1 and 4: Reflection**
  - Direct students to access the flashcard example as you review the vocabulary term *reflection*.
  - Students use mirrors and a laser light to explore reflection.
  - Students first use the mirrors to look at their own reflection. They discuss in their groups what causes them to be able to see their reflections in mirrors, and not in other objects.
  - Students then use lasers to reflect light off the mirrors.
  - Students draw an image in their Launch Logs depicting angles of measurement in reflecting light.



  - As an extension, groups can try to reflect the laser from mirror to mirror.
- **Centers 2 and 5: Materials Sort**
  - Students sort your prepared materials as transparent, translucent, and opaque. They record their results in their Launch Logs.

- **Centers 3 and 6: Bending Light Simulation**
  - Students use a digital device to complete the **PhET Bending Light** simulation Intro with a partner.

7. Guide students to rotate through the three learning centers to explore more about waves and light. As previously noted, you can pull out any of the center activities as separate activities to accommodate effective facilitation for your situation.

8. As students rotate through the centers, observe students interacting with the materials. Use the guiding questions found at the end of each centers section in the student course to assess student learning throughout the activity.

9. Lead students in a discussion of what they discovered through the centers.

Reflection

- What did you notice about the angle measurements to get the light to reflect from mirror to mirror?
- What are some objects in your everyday life that you notice light reflects off of?
- What needs to occur with light to allow us to see?

Materials Sort

- How does light pass through differently in opaque, translucent, and transparent objects?
- In what ways are opaque, translucent, and transparent objects used in our daily lives?

Bending Light Simulation

- What did you notice about the angle measurements during reflection?
- What did you notice about the angle measurements during refraction?

10. Direct students to record responses in the "L" column of the KWL chart in their Launch Logs. Ask students to share their responses and add to the class KWL chart.

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

Conclusion Questions Answer Key

1. How do the properties of light allow us to see things differently? Use evidence from the centers to explain.

Student responses should demonstrate an understanding of light. Responses might include:
Light is a form of energy, so it moves and bends depending on the type of material it interacts with. For example, when light interacts with an opaque object, it creates a shadow because no light can go through.

2. How does the behavior of light affect our daily lives?

Student responses should demonstrate an understanding of light. Responses might include:
We use transparent, translucent, and opaque materials for different purposes in our daily lives. For example, in my home we have transparent windows. Over the windows we have both translucent and opaque curtains so we can choose the amount of light that comes in at any time.

Problem

Design a Game

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
• VEX® IQ PLTW Light Game (1 set per group) • Optional: ◦ Flashlights ◦ Color filter cards	• PLTW Launch Logs (1 per student) • Digital devices • Pencils or colored pencils for sketching • Games with rule books such as: ◦ Board games ◦ Card games • Optional materials such as: ◦ VEX IQ Construction Kits ◦ Paper ◦ Tape ◦ Dice ◦ Cards	• Inkling • Camera • Digital product apps, such as: ◦ Popplet Lite ◦ Mindomo ◦ ShowMe Interactive Whiteboard

RESOURCES

R

Decision Matrix

Summative Assessment

ESSENTIAL QUESTIONS

EQ

EQ1 How are waves used to predict results and solve problems?
EQ2 How do the properties of light allow us to see?
EQ3 How can we use patterns to make sense of the world?
EQ4 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.
LO3 Develop a model of the interaction between light and matter.
LO5 Collaborate effectively on a diverse and multidisciplinary team.
LO6 Communicate effectively for specific purposes and settings.
LO7 Practice ethical behavior in all settings.

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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.
- KS3.1 Identify unique properties of light.
- KS3.3 Describe that when light bounces back from an object, it is called reflected light.
- KS3.5 Describe the movement of light as it passes through different substances as transparent, translucent, or opaque.
- 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.
- 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. Collect some games, such as board games and card games, and their rule books. Students will use them to do research during the Explore portion of the design process.
2. Anticipate additional resources students may want to use as they design their games, such as paper, tape, dice, and cards.
3. Have the VEX IQ PLTW Light Game sets ready for students to use.
4. 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.
5. 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

A laser beam is visible as it travels through air or space. Light from a laser, just like other colors of light, is not visible unless it reflects off an object. Dust or small particles in the air might reflect enough light for the beam to be seen.

Time: 210 Minutes

Introduction

In this problem, students work in small groups to design a game that uses *light* and its *patterns*. Students use the *design process* to develop their game using the knowledge they have learned throughout the module. They create a rule book and use available equipment to challenge others and test their design.

design process	A step-by-step way to solve problems.
constraint	A limitation or a restriction. Constraints include limits on time, materials, and size.
criteria	Guidelines or rules used to make a decision about something.
light	The form of energy or electromagnetic radiation that makes it possible to see things.
opaque	The property of blocking out all light. Light shining on an opaque object creates a shadow.
reflection	The return of waves from a surface.
translucent	The property of allowing some light to pass through. You cannot see completely through a translucent object.
transparent	The property of allowing almost all light to pass through. You can see through a transparent object.

Procedure

1. Direct students to access the problem in the student course and have them read the Introduction. As you guide them to review the problem statement, allow students to share their thoughts and excitement about designing a game that uses light.
2. Lead a discussion to review light and its patterns.

   - What is light? Direct students to select the flashcard example to review the vocabulary term *light*.
   - What properties are associated with light? Direct students to select the flashcard examples to review the vocabulary terms *reflection*, *transparent*, *translucent*, and *opaque*.

3. Introduce to students that they will use a design process to guide their work on solving the problem.

- 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 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? Direct students to access the flashcard example as you review the vocabulary term *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 Explain to the students that they are going to use the design process to design a game that uses light and its properties. Students will prepare a physical model of a game with its rules and share the game with their classmates.

7 Put students in groups of two to four.

8 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 their game. Remind students to include details that provide evidence of their thinking.

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

- With support and guidance, the students define the problem, "How can we design a game using the properties of light?"
- Use the flashcard examples to introduce the vocabulary terms *criteria* and *constraint*.
- Introduce the criteria and constraints of the design.

Criteria	Constraints
• The group must design, build, and test a game that incorporates light. • The game must be able to be played with two to four people. • The game must include: ▪ A rule book ▪ Lasers (one or two) ▪ 12x12 plates (one to four) ▪ Reflection ▪ Transparent, translucent, and/or opaque materials	• Time • Materials: ▪ VEX IQ PLTW Light Game ▪ Other materials as determined by teacher

- 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**.

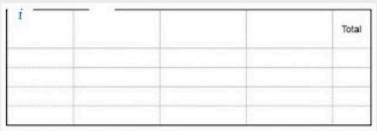
- Guide students to research rules that are used in different games. Encourage students to review board games, card games, and more to gain inspiration for their design.

> **Note**: Some common sections of rule books include:
> - Title of game
> - Introduction
> - Object of the game
> - Equipment
> - Preparation
> - How to play
> - End of the game
> - Winning the game

- 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.
- 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 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 game design. Using the **Decision Matrix**, students rate each group member's game based on a 0–1 scale for each category. If the game does not meet the criterion for a category, it receives a 0 in that category. If the game does meet the criterion, it receives a 1. The game 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 game.
- Remind students to revisit the criteria so their game contains all elements.
- To facilitate creation of the games, 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**.

- Direct students to swap their rule book and game equipment with another group. Allow students time to play each others' games.
- Guide groups to give each other feedback on the strengths and weaknesses of their games. Have them consider:
  - How could the rule book be improved?
  - What other ways could the properties of light be included?
  - How could the game be more engaging?
- Guide groups to reflect on the strengths and weaknesses of their own design after receiving feedback.
- After students identify the strengths and weaknesses of their game, 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.

13 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 game, with annotations describing the experience their testing group had when they played the game
- Strengths and weaknesses
- Ways to improve the design

- Allow time for students to share their presentations.
- After all presentations, lead a discussion about the features, strengths, and weaknesses of the different designs.

- What key takeaway do you have after viewing all the presentations?
- If you could improve anything about your game, what would you improve? Why would you improve that aspect?
- If you could create a new game, what would you include? Why would you include that?

- Guide students to complete the Explain section of their Launch Logs. Have students provide suggestions for improvement to their game 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 Waves and Their Applications 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 game design successful? Support your answer with the evidence you recorded in your Launch Log.

Student responses will vary.

2 List two changes you would make to improve the design. Why do you think these changes would improve your game model?

Student responses will vary.

3 In this problem, you designed a game that incorporated the properties of light. If you were to design a game without any criteria or constraints, what would you design?

Student responses will vary.



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



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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