Grade 4, Science, Unit 1, Weathering and Erosion

Content Area:	**Science**
Course(s):	**Science**
Time Period:	**September**
Length:	**4 weeks**
Status:	**Published**

Next Generation Science Standards

SCI.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.
SCI.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.
SCI.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.

Student Learning Objectives

- Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon. (4-ESS2-1)
- Identify the evidence that supports particular points in an explanation. (4-ESS1-1)
- 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)
- Living things affect the physical characteristics of their regions. (4-ESS2-1)
- 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)
- Cause and effect relationships are routinely identified, tested, and used to explain change. (4-ESS2-1)
- Patterns can be used as evidence to support an explanation. (4-ESS1-1)

Enduring Understanding

Earth's components form systems that continually interact affecting the Earth regionally and globally.

Essential Questions

How can evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation be observed or measured?

What can rock formations tell us about the past?

Assessment

Students who understand the concepts can:

- Identify, test, and use cause-and-effect relationships in order to explain change.
- Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon.
- Make observations and/or measurements to produce evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation. *(Note: Assessment is limited to a single form of weathering or erosion.)* Examples of variables to test could include:
- Angle of slope in the downhill movement of water
- Amount of vegetation
- Speed of the wind
- Relative rate of deposition
- Cycles of freezing and thawing of water
- Cycles of heating and cooling

- Volume of water flow

Students who understand the concepts can:

- Support explanations using patterns as evidence.
- Identify the evidence that supports particular points in an explanation.
- Identify evidence from patterns in rock formations and fossils in rock layers to support an explanation for changes in a landscape over time. *(Note: Assessment does not include specific knowledge of the mechanism of rock formation or memorization of specific rock formations and layers. Assessment is limited to relative time.)* Examples of evidence from patterns could include

Rock layers with marine shell fossils above rock layers with plant fossils and no shells, indicating a change from land to water over time.

A canyon with different rock layers in the walls and a river in the bottom, indicating that over time a river cut through the rock.

Instructional Activities

- **Lesson Plans - Grade 4 Science**
- StreamTable Activities (add houses, delta, canyon, etc.)

In this unit of study, students are expected to develop understanding of the effects of weathering and the rate of erosion by water, ice, wind, or vegetation. As students plan and carry out investigations using models and observe the effects of earth processes in the natural environment, they learn to identify patterns of change; recognize cause-and-effect relationships among the forces that cause change in rocks, soil, and landforms; and construct explanations of changes that occur over time to earth materials.

In the first portion of the unit, fourth graders develop an understanding of cause-and-effect relationships when studying physical weathering and the rate of erosion by water, wind, ice, or vegetation. Students learn that rainfall helps to shape the land and affects the types of living things found in a region, and that living things affect the physical characteristics of a region. Students should make observations of their local environment to observe the types of living things that are common in the region, and they should look for evidence that water, ice, wind, organisms, and gravity have broken down rocks, soils, and sediments into smaller pieces and have moved them from one place to another.

In the classroom, students should build and use models that demonstrate how wind, water, and ice cause change to the surface of the earth. Students should use stream tables, soil, sand, and water to simulate the effects of moving water (rain, rivers) on rocks and soil. Following these types of experiences, students need opportunities to ask questions that will lead to further investigations. They can change a variable—such as the type of earth material (sand, soil, clay, silt), the angle of a hill's slope, the volume of water flow, the speed of water flow, and the relative rate of deposition—then collect and analyze data in order to determine the effects.

In addition to using models to understand the effects of water and ice on land, students should build and use models to simulate the effects of wind on earth materials. There are a variety of models that can be easily built. Students should have opportunities to change variables, such as the speed or volume of airflow. From these experiences, students should begin to understand that wind, water, and ice cause changes to the earth's surface, and that the stronger or faster the flow of wind or water, the greater the change it causes.

In this unit, students also need opportunities to observe ways in which plants affect the weathering and erosion of earth materials. Plants can have a variety of effects on rocks, soils, and landforms. Plants often slow or stop the effects of moving wind and water on land. Students can observe this phenomenon using models. As they make observations, students can change variables, such as the amount or type of plant used to slow or stop erosion, and they can collect and analyze data to determine cause-and-effect relationships between the amount of change and the plants used to prevent it. Then students can walk around the schoolyard and nearby neighborhoods to look for examples of plants that are used to prevent erosion.

In addition to slowing or preventing erosion, plants can cause weathering of rocks. Students can easily find examples in their own environment of growing plant and tree roots causing rocks, sidewalks, and driveways to crack and break down into smaller and smaller components. This phenomenon can also be simulated with models in the classroom. Students can soak lima beans in water overnight, then "plant" them in small cups containing a 2–3 cm. layer of wet Plaster of Paris on top of potting soil. (One or two seeds should be placed in the wet layer of plaster.) After a few days, the seeds will germinate and grow, eventually causing the dried plaster to crack. Again, students need opportunities to change variables, such as the number of seeds planted (one seed vs. multiple seeds, for example) and the type of seeds, then make observations and collect data to determine the amount of weathering each change causes to the dried plaster.

In the second portion of this unit, students learn that patterns can be used as evidence to explain changes to the earth's landforms and rock formations, and that local, regional, and global patterns of rock formations reveal changes over time due to earth forces. If possible, students should make observations of local landforms; however, pictures from books and online sources can give students the opportunity to identify evidence of change from patterns in rock formations and fossils in rock layers. Students can support explanations for changes in a landscape over time in multiple ways, including the following:

- Pictures of a variety of landforms, such as sand dunes and canyons, can be used to show change due to weathering and erosion that have occurred over time.
- Pictures or diagrams of rock layers with marine shell fossils above rock layers with plant fossils and no shells can be used to indicate a change from land to water over long periods of time.
- Pictures of a canyon with different rock layers in the walls and a river at the bottom can be used to show that over time a river cut through the rock to form the canyon.

As students collect evidence, either from firsthand observations or from media resources, they should attempt to explain the changes that have occurred over time in each of the landscapes observed.

Interdisciplinary Connections

ELA

Conduct short research projects that build knowledge through investigation of different aspects of a topic. (4-ESS1-1) **W.4.7**

Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources. (4-ESS2-1)**,**(4-ESS1-1)**W.4.8**

Draw evidence from literary or informational texts to support analysis, reflection, and research. (4-ESS1-1) **W.4.9**

MATH

Reason abstractly and quantitatively. (4-ESS2-1), (4-ESS1-1) **MP.2**

Model with mathematics. (4-ESS2-1), (4-ESS1-1) **MP.4**

Use appropriate tools strategically. (4-ESS2-1) **MP.5**

Know relative sizes of measurement units within one system of units including km, m, cm; kg, g; lb, oz.; l, ml; hr, min, sec. Within a single system of measurement, express measurements in a larger unit in terms of a smaller unit. Record measurement equivalents in a two-column table. (4-ESS2-1), (4-ESS1-1) **4.MD.A.1**

Use the four operations to solve word problems involving distances, intervals of time, liquid volumes, masses of objects, and money, including problems involving simple fractions or decimals, and problems that require expressing measurements given in a larger unit in terms of a smaller unit. Represent measurement quantities using diagrams such as number line diagrams that feature a measurement scale. (4-ESS2-1) **4.MD.A.2**

Texts and Resources

NJ Model Curriculum Unit 1 Weathering and Erosion

Weathering and Erosion Activities

Bill Nye the Science Guy Video

Student Reading Passages - ReadWorks - Erosion

Reading Passage/Question Set

Weathering and Erosion Experiment

Reading Library List - Science Related

Teaching NGSS in Elementary School-Fourth Grade

The web seminar began with an introduction to NGSS, its framework for K-12 science education, and its cross-cutting concepts and core ideas by NSTA's Ted Willard. Mary Starr, Executive Director of Michigan Mathematics and Science Centers Network and Kathy Renfrew, K-5 Science Coordinator for VT Agency, began with a look into disciplinary core ideas, using the example of energy, and how they apply to the fourth grade in terms of performance expectations and an approach to science and engineering practices. Kathy also brought a special guest with her, Tracy Lavallee, a teacher from Vermont featured in the web seminar's videos. Using two videos taken from Tracy's fourth grade classroom, lesson plan ideas and approaches were discussed and teachers were able to share their thoughts and approaches on the classroom activities. A number of NSTA Learning Center tools and resources were shared as well a number of website links for further investigation. The session concluded with some final words from Ted and a Q/A.

Visit the resource collection.

Continue discussing this topic in the community forums.

Glaciers, Water, and Wind, Oh My! This hands-on activity allows students to explore five earth forces that may cause erosion as they model, observe, and record the effects of erosion on earth surfaces. Stations include demonstrations of chemical, wind, water, ice and heat forces as they affect weathering.

Bill Nye Video-Erosion: Bill Nye, "The Science Guy", presents a video describing the effects of weathering (wind, water, ice) on landforms. Bryce Canyon is used as an example of the ways in which freezing water, plant roots, and wind weather the earth's surface creating the means for erosion. Students in video simulate effects of weathering which can be duplicated in a classroom setting. Nye also emphasizes the passage of time in millions of years as he explains the slower erosive effects of certain types of weathering.

Gary's Sand Journal: This book allows students to observe illustrations of magnified sand particles with guided dialogue from an earth scientist who discusses sand origins. This book can be used to introduce students to types of sand, explain how earth processes were responsible for their creation, and discuss the work of earth scientists. After reading this book, students may use it as a resource when examining their own sand samples. They could list properties, discuss sand origins, and illustrate samples in a science journal.

Explaining Glaciers, Accurately: Fourth grade lessons on glacial erosion demonstrate and explain the manner in which glaciers erode the earth. The mechanisms of plucking and abrasion are discussed. Activities (either whole-class or small group) include a teacher creation of a glacier model (using dirt and rocks to simulate a mountain, ice cubes and a small amount of water for glacier), then teacher demonstration of glacier "plucking" earth as it travels in a simulation activity. Students then experiment with rock samples, wood, sandpaper, and ice as they rub materials against each other to explore how glacial striations form and abrade other surfaces. In each simulation, students are asked to predict what would happen when glacial model water freezes, as they draw before and after pictures of the model. Students are also asked to predict how glacial striations were formed as they view photos, then record results of their abrasive materials activity. Students could benefit from the expertise of a mentoring geologist who shares illustrations and information with students and teachers.
Coastal Erosion: This engineering design lesson focuses on the effects of erosion on Florida's coastline. It is one lesson offered within a larger weathering and erosion unit. Students groups work to create and use a model able to slow erosion, without damaging the coastal ecosystem. Students are responsible for developing scale diagram of their coastline erosion solution before building and testing their models in a pan to simulate the coastline. Students then complete a redesign cycle. Similar lessons from the developer can be used in conjunction with this lesson to incorporate the effects of erosion on humans and wildlife.

NSTA Web Seminar: Teaching NGSS in K-5: Constructing Explanations from Evidence

Carla Zembal-Saul, Mary Starr, and Kathy Renfrew, provided an overview of the *NGSS* for K-5th grade. The web seminar focused on the three dimensional learning of the *NGSS*, while introducing CLAIMS-EVIDENCE-REASONING (CER) as a framework for introducing explanations from evidence. The presenters highlighted and discussed the importance of engaging learners with phenomena, and included a demonstration on using a KLEWS chart to map the development of scientific explanations of those phenomena.

To view related resources, visit the resource collection.

Continue discussing this topic in the community forums.

NGSS *Core* Ideas: Earth's Place in the Universe

The presenter was Julia Plummer from Penn State University. The program featured strategies for teaching about Earth science concepts that answer questions such as "What goes on in stars?" and "What patterns are caused by Earth's movements in the solar system?"

Dr. Plummer began the presentation by discussing what students should know about the disciplinary core idea of Earth's Place in the Universe. She talked about using the scientific and engineering practices to help engage students. Participants shared their ideas about applying this core idea to the classroom, and then Dr. Plummer shared strategies for effective instruction. She also discussed the importance of spatial thinking for students to begin thinking scientifically about these concepts.
Continue the discussion in the community forums.

Grade 4, Science, Unit 2, Earth Processes

Content Area: **Science**
Course(s): **Science**
Time Period: **October**
Length: **4 Weeks**
Status: **Published**

Next Generation Science Standards

SCI.4-ESS2-2	Analyze and interpret data from maps to describe patterns of Earth’s features.
SCI.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.
SCI.4-ESS3-2	Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.

Student Learning Objectives

- Analyze and interpret data to make sense of phenomena using logical reasoning. (4-ESS2-2)
- Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution. (4-ESS3-2),(3-5-ETS1-2)
- 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)
- 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)
- 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.)*
- Testing a solution involves investigating how well it performs under a range of likely conditions. *(secondary to 4-ESS3-2*)
- Research on a problem 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)

- 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)

Enduring Understanding

Technology enables us to better understand Earth's systems and the impact of Earth's systems on human life and activities.

Humans cannot eliminate natural hazards but can take steps to reduce their impact.

A variety of natural hazards result from natural processes.

Essential Questions

What can maps tell us about the features of the world?

In what ways can the impacts of natural Earth processes on humans be reduced?

Assessment

Students who understand the concepts are able to:

- Identify and test cause-and-effect relationships in order to explain change.
- Generate multiple solutions to a problem and compare them based on how well they meet the criteria and constraints of the design solution.
- Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans *(Limited*

to earthquakes, floods, tsunamis, and volcanic eruptions.)

Examples of solutions could include:

- Designing an earthquake-resistant building
- Improving monitoring of volcanic activity.
- Generate multiple possible solutions to a problem and compare them based on how well each is likely to meet the criteria and constraints of the problem.
- 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.

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.

Instructional Activities

- Design a house out of sugar cubes - using science journal. Movement to the table, create earthquake. Require so many windows, etc. Determine that windows and door frames are weak point - develop questioning by evaluating the weak areas and how to make stronger.
- Study destruction of earthquakes by analyzing images - real world. (What is building made out of, height of building, etc.)

In this unit of study, students analyze and interpret data from maps to describe patterns of Earth's features. Students can use topographic maps of Earth's land and ocean floor in order to locate features such as mountains, mountain ranges, deep ocean trenches, and other ocean floor structures. As students analyze and interpret these types of maps, they begin to notice patterns in the types of structures and where these structures are found. Students learn that major mountain chains often form along or near the edge of continents. Once students locate continental boundaries, a further analysis of data can show students that there is a noticeable pattern of earth events, including volcanoes and earthquakes, which occur along these boundaries.

During this unit, students also learn that engineers develop or improve technologies to solve societal problems. A variety of hazards result from natural processes (e.g. earthquakes, floods, tsunamis, volcanic eruptions). Although we cannot eliminate the hazards, we can take steps to reduce their impacts. Students must have the opportunity to engage in the engineering design process in order to generate and compare multiple solutions that reduce the impacts of natural Earth processes on humans. This process should include the following steps:

- Students brainstorm possible problems that Earth processes can cause for humans. (Earth processes should be limited to earthquakes, volcanic eruptions, tsunamis, and floods.)
- Either as a class or in small groups, have students select one problem (such as the effects of volcanic eruptions on humans) to research.
- Small groups conduct research to determine possible solutions (such as consistent monitoring of volcanic activity and the use of early warning systems) that reduce the impacts of the chosen Earth process on humans.
- As a class, determine criteria and possible constraints on the design solutions. Criteria might include: saving lives and/or reducing property loss.

Small groups investigate how well the solutions perform under a range of likely conditions. This may involve additional research and analysis of available data or planning and conducting investigations to produce data that will serve as the basis for evidence. During this process, students should plan and carry out fair tests in which variables are controlled and failure points are considered in order to identify elements of the design solution that do and do not meet criteria.

Students compare the solutions based on how well they meet criteria and constraints, using data as evidence to support their thinking. At every stage, communicating with peers is an important part of the design process, because shared ideas can lead to improved designs. Students should routinely identify and test cause-and-effect relationships and use these relationships to explain the changes that they observe as they test design solutions.

At every stage, communicating with peers is an important part of the design process, because shared ideas can lead to improved designs. Students should routinely identify and test cause-and-effect relationships and use these relationships to explain the changes that they observe as they test design solutions.

Engineering design performance expectations are an integral part of this unit of study. Students are expected to research a problem, generate and compare possible design solutions, and test the design solutions to determine how well each performs under a range of likely conditions. Using data as evidence, students identify elements of each design that need improvement and determine which design solution best solves the problem, given the criteria and the constraints. This process is outlined in greater detail in the previous section.

Interdisciplinary Connections

ELA

Refer to details and examples in a text when explaining what the text says explicitly and when drawing inferences from the text. (4-ESS3-2) **RI.4.1**

Interpret information presented visually, orally, or quantitatively (e.g., in charts, graphs, diagrams, time lines, animations, or interactive elements on Web pages) and explain how the information contributes to an understanding of the text in which it appears. (4-ESS2-2) **RI.4.7**

Interpret information presented visually, orally, or quantitatively (e.g., in charts, graphs, diagrams, time lines, animations, or interactive elements on Web pages) and explain how the information contributes to an understanding of the text in which it appears. (4-ESS2-2) **W.4.7**

Integrate information from two texts on the same topic in order to write or speak about the subject knowledgeably. (4-ESS3-2) **RI.4.9**

Quote accurately from a text when explaining what the text says explicitly and when drawing inferences from the text. (3-5-ETS1-2) **RI.5.1**

Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently. (3-5-ETS1-2) **RI.5.1**

Integrate information from several texts on the same topic in order to write or speak about the subject knowledgeably. (3-5-ETS1-2) **RI.5.9**

Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic. (3-5-ETS1-3) **W.5.7**

Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources. (3-5-ETS1-3) **W.5.8**

Draw evidence from literary or informational texts to support analysis, reflection, and research. (3-5-ETS1-3) **W.5.9**

MATH

Use the four operations to solve word problems involving distances, intervals of time, liquid volumes, masses of objects, and money, including problems involving simple fractions or decimals, and problems that require expressing measurements given in a larger unit in terms of a smaller unit. Represent measurement quantities using diagrams such as number line diagrams that feature a measurement scale. 4-ESS2-2) **4.MD.A.2**

Reason abstractly and quantitatively. (4-ESS3-2), (3-5-ETS1-2),(3-5-ETS1-3) **MP.2**

Model with mathematics. (4-ESS3-2), (3-5-ETS1-2),(3-5-ETS1-3) **MP.4**

Interpret a multiplication equation as a comparison, e.g., interpret 35 = 5 × 7 as a statement that 35 is 5 times as many as 7 and 7 times as many as 5. Represent verbal statements of multiplicative comparisons as multiplication equations. (4-ESS3-2) **4.OA.A.1**

Use appropriate tools strategically. (3-5-ETS1-2),(3-5-ETS1-3) **MP.5**

Operations and Algebraic Thinking (3-ETS1-2) **3-5.OA**

Texts and Resources

NJ Model Curriculum Unit 2 - Earth Processes

Introductory Presentation - Earth Processes

Interactive Lesson

Google Earth Lesson Plans

Earthquakes in the Classroom: Students investigate which building types are structured to withstand earthquake damage. They take on the role of engineers as they design their own earthquake resistant buildings, then test them in a simulated earthquake activity. Students also develop an appreciation for the job of engineers who need to know about earthquakes and their causes in order to design resistant buildings. This lesson is one of several in the

"Earthquakes Rock" unit provided by the Teach Engineering site. The unit "URL" listed here is not being reviewed for the Performance Expectation listed. It is offered as a supplemental concept and lesson background aid for teachers. https://www.teachengineering.org/view_activity.php?url=collection/cub_/activities/cub_natdis/cub_natdis_lesson03.xml

Getting the Right Angle on the Story: This informational text shows students how tsunamis form and behave. It also describes how scientists are collecting data to create models that can be used to predict tsunamis. Animations/computer models are also included to enhance student knowledge of how tsunami warnings work. Models integrate new, unfamiliar vocabulary. Students could use the resource as a starting point for an earth systems unit; teachers could assign the site as a form of research where students gather data, take notes, and draw inferences from text. As students begin their study, they could generate a list of the earth's natural disasters and define their impact on human life and the environment. Their possible solutions for lessening that impact could also be incorporated as an informal formative assessment to determine student prior knowledge.

DLESE Earth Science Literacy Maps are a tool for teachers and students to find resources that relate to specific Earth science concepts. These maps illustrate connections between concepts and how they build upon one another across grade levels. Clicking on a concept within the maps will show DLESE resources related to the concept, as well as information about related AAAS Project 2061 Benchmarks and National Science Education Standards.

Engineering for the Three Little Pigs: This activity helps to demonstrate the importance of rocks, soils, and minerals in engineering and how using the right material for the right job is important. The students build 3 different sand castles composed of varying amounts of sand, water, and glue. The 'buildings' in this lesson are made of sand and glue, sand being a soil and glue being composed of different minerals. They then test them for strength (load bearing), and resistance to weathering. The students will then compare possible solutions and discuss how well each is likely to work while meeting the criteria and constraints of the problem. The students will be the engineers who figure out which materials are best for the buildings they are making, taking into consideration all the properties of materials that are discussed in the lesson.

Building for the Big One: This lesson plan details a Design Challenge in which students build and test structures while learning about the earthquakes that shake them. It is designed as a review or culmination of an Earthquake unit of study. The lesson plan allows teachers to connect back to previous lessons. The Tech Museum of Innovation also suggests that the lesson might be used as a form of introduction to a unit about earthquakes. The lesson would then be used to determine students' prior knowledge to set the stage for the design challenge. This resource often mentions the effects of tectonic plates on earthquake location. Grade 4 curriculum does not include tectonic plates in their earth science curriculum. Tectonic plate information is included in the lesson as a resource for the teacher.

Using the NGSS Practices in the Elementary Grades

The presenters were Heidi Schweingruber from the National Research Council, Deborah Smith from Penn State University, and Jessica Jeffries from State College Area School District. In this seminar the presenters talked about applying the scientific and engineering practices described in A Framework for K–12 Science Education in elementary-level classrooms.

Continue the discussion in the community forums.

***NGSS* Core Ideas: Earth's Systems**

The presenter was Jill Wertheim from National Geographic Society. The program featured strategies for teaching about Earth science concepts that answer questions such as "What regulates weather and climate?" and "What causes earthquakes and volcanoes?"

Dr. Wertheim began the presentation by introducing a framework for thinking about content related to Earth systems. She then showed learning progressions for each concept within the Earth's Systems disciplinary core idea and shared resources and strategies for addressing student preconceptions. Dr. Wertheim also talked about changes in the way NGSS addresses these ideas compared to previous common approaches. Participants had the opportunity to submit questions and share their feedback in the chat.

Continue the discussion in the community forums.

Grade 4, Science, Unit 3, Structure and Function

Content Area: **Science**
Course(s): **Science**
Time Period: **November**
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Next Generation Science Standards

SCI.4-LS1-1	Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.

Student Learning Objectives

- Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction. (4-LS1-1)
- Construct an argument with evidence, data, and/or a model. (4-LS1-1)
- A system can be described in terms of its components and their interactions. (4-LS1-1)

Enduring Understanding

Interactions between living things create a flow of energy. All living organisms have identifiable structures and characterteristics that allow for survival (organisms, populations, species).

Essential Questions

How do internal and external parts of plants and animals help them to survive, grow, behave, and reproduce?

How do organisms depend on each other to survive?

How are organisms of the same kind different from each other?

How does this help them reproduce and survive?

Assessment

Students who understand the concepts are able to:

- Describe a system in terms of its components and their interactions.
- Construct an argument with evidence, data, and/or a model.
- Construct an argument to support the claim that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction. *(Assessment is limited to macroscopic structures within plant and animal systems.)* Examples of structures could include:

Thorns

Stems

Roots

Colored petals

Heart

Stomach

Lung

Brain

Skin

Instructional Activities

In this unit of study, students spend time observing plants and animals in order to gather evidence that organisms are living systems. A system is made up of structures and processes that interact and enable the system to function. Every plant and animal can be described in terms of its internal and external structures and their interactions, and these structures each have specific functions that support survival, growth, behavior, and reproduction for the organism.

Using a variety of plants and animals as examples, students need multiple opportunities to:

- Describe the internal and external structures of a plant or animal and the function of each of those structures. Description should explain how each structure serves various functions in growth, survival, behavior, and/or reproduction*. (Note: This is limited to macroscopic structures within plant and animal systems, and could include such structures as thorns, stems, roots, and colored petals for plants, and heart, stomach, lung, brain, and skin for animals.)*

- Describe the interactions that occur among the structures within the plant or animal system.

As students observe the structures of an animal or plant, explain the function of each, and describe how these structures help the animal grow, survive, and/or reproduce, they should use evidence from their observations to support their explanations.

Interdisciplinary Connections

ELA

Write opinion pieces on topics or texts, supporting a point of view with reasons and information. (4-LS1-1) **W.4.1**

Recognize a line of symmetry for a two-dimensional figure as a line across the figure such that the figure can be folded across the line into matching parts. Identify line-symmetric figures and draw lines of symmetry. (4-LS1-1) 4.G.A.3

Texts and Resources

NJ Model Curriculum Unit 3 - Structure and Function

Animal Mouth Structures

In this lesson, students gather evidence to understand features that enable them to meet their needs. In particular, they examine the mouth structures of different animals to help them understand how animals are adapted to obtain food in their environment.

Connections Between Practices in *NGSS*, Common Core Math, and Common Core ELA

The presenter was Sarah Michaels from Clark University. In this seminar Dr. Michaels talked about connecting the scientific and engineering practices described in A Framework for K–12 Science Education with the Common Core State Standards in Mathematics and English Language Arts.
NJ Model Curriculum Unit 3 Structure and Function

Engineering Design as a Core Idea

The presenter was Cary Sneider, Associate Research Professor at Portland State University in Portland, Oregon. The seminar focused on the Core Idea of Engineering, led by Cary Sneider, Associate Research Professor at Portland State University. Cary explained the overall *NGSS* engineering components for K-2, MS and HS, and went through a number of practical examples of how teachers could develop modules and investigations for their students to learn them. Cary also spoke about the ways in which teachers could include cross-cutting engineering concepts to a number of classroom subjects. The seminar concluded with an overview of NSTA resources about *NGSS* available to teachers by Ted, and a Q & A session with Cary.

Visit the resource collection.

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NGSS Core Ideas: From Molecules to Organisms: Structures and Processes

The presenters were Aaron Rogat of Educational Testing Service (ETS) and Barbara Hug of the University of Illinois at Urbana-Champaign. The program featured strategies for teaching about life science concepts that answer questions such as "How do the structures of organisms enable life's functions?" and "How do organisms grow and develop?"

Dr. Hug began the presentation by discussing the arrangement of life science core ideas within *NGSS* and comparing them to previous standards. Next, Dr. Rogat shared an example of a learning progression, showing how a concept can be taught from early elementary through high school. The presenters then talked about strategies for instruction and shared links to resources. Participants had the opportunity to submit their questions and comments in the chat.

Visit the resource collection.

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Annenberg Media's Teachers' Resources are short video courses covering essential science content for K-6 teachers.

Grade 4, Science, Unit 4, How Organisms Process Information

Content Area: **Science**
Course(s): **Science**
Time Period: **December**
Length: **4 weeks**
Status: **Published**

Next Generation Science Standards

SCI.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.
SCI.4-PS4-2	Develop a model to describe that light reflecting from objects and entering the eye allows objects to be seen.

Student Learning Objectives

- Use a model to test interactions concerning the functioning of a natural system. (4-LS1-2)
- Develop a model to describe phenomena. (4-PS4-2)
- 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)
- An object can be seen when light reflected from its surface enters the eyes. (4-PS4-2)

Enduring Understanding

Groups of organisms show evidence of change over time (e.g. evolution, natural selection, structures, behaviors, and biochemistry).

Essential Questions

How do animals receive and process types of information from their environment in order to respond appropriately?

How do internal and external structures support the survival, growth, behavior, and reproduction of plants and animals?

How do the structures of organisms contribute to and enable life's functions?

Assessment

Students who understand the concepts are able to:

- Describe a system in terms of its components and their interactions.
- Use a model to test interactions concerning the functioning of a natural system.
- 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.

ü Emphasis is on systems of information transfer.

Assessment does not include the mechanisms by which the brain stores and recalls information or the mechanisms of how sensory receptors function.

Students who understand the concepts are able to:

- Identify cause-and-effect relationships.
- Develop a model to describe phenomena.

Develop a model to describe that light reflecting from objects and entering the eye allows objects to be seen. (Assessment does not include knowledge of specific colors reflected and seen, the cellular mechanisms of vision, or how the retina works).

Instructional Activities

In this unit of study, students use the concept of *systems* to understand that every animal has internal and external structures that allow it to take in information from the environment in which it lives, process that information, and respond in ways that increase its chances to grow, reproduce, and survive.

The way in which an organism gathers information will depend on the organism and the body structures that pick up signals from the environment. Many animals, like humans, have sense organs that gather information from the environment through seeing, hearing, feeling, smelling, and tasting. Some animals have sensory receptors or other mechanisms that allow them to sense such things as light, temperature, moisture, and movement. Students need to understand that all animals pick up information from their environment through senses or sensory receptors. In many animals, nerves or neurons then transfer that information to a centralized place (the brain) where it is processed; then, through reflex reactions or learned behaviors, the organism responds in ways that will help it survive and reproduce. In addition, animals often store this information in their brains as memories and use these memories to guide future actions. As students observe animals, either through direct observation or using text and digital resources, they should use models, such as drawings, diagrams, and pictures, to describe the ways that animals (and humans) receive, process, store, and respond to information from the environment in order to survive, grow, and reproduce.

To continue the progression of learning, fourth graders focus on the sense of sight, using models to understand and describe that light reflects from objects and enters the eye, allowing objects to be seen. In first grade, students learned that objects can be seen only when illuminated, and they determined the effect of placing different materials in the path of a beam of light. In this unit, students need opportunities to develop a conceptual understanding of the role that light plays in allowing us to see objects. Using a model can help with this process, which might include the following steps:

To review prior learning, ask students to describe what happens to our ability to see objects in a room with no light, and what happens when different types of materials are placed in the path of a beam of light. (If necessary, demonstrate using flashlights and a variety of transparent, translucent, and opaque materials).

Using penlights, a variety of lenses, mirrors, and pieces of cardboard, allow students to explore the behavior of light when it comes into contact with these objects. Have students draw and describe what they observe.

Using a cardboard shoebox with a 1-cm. slit at one end, shine a flashlight into the box through the slit, and ask students to describe what they see. Place a clear plastic cup of water in the path of the light, and ask students to describe what they observe.

- Students should first observe that light travels in a straight line. Lenses and water allow the light to pass through; however, the beam of light is refracted (bent). Mirrors do not allow the light to pass through, but do reflect light, sending the beam in a different direction. The cardboard does not allow any light to pass through, and the beam of light is no longer visible in the same way.

Next have students observe a large object, such as a book. Ask them to describe what they see. Place a sheet of transparency film or clear plastic wrap in front of the book, and ask students to again describe what they see. Ask, "How are you able to see the book even though I have placed something in between you and the object?"

- Take away the clear plastic wrap and place a sheet of dark construction paper in front of the book, and ask student to describe what they see. Ask, "Why are you no longer able to see the book?"

To help students as they try to understand the role that light plays in allowing us to see objects, tell them that they will be using a model that demonstrates how we see objects.

Have students use pinhole viewers. (If possible, make these ahead of time. You can find a variety of models and types that are easy to build on the Internet. YouTube has a number of videos that show pinhole viewers made from a variety of materials such as a Pringles tube or black poster board.) Show students how the pinhole viewers are constructed and what is inside each. Then have students go outside and view objects using the pinhole viewers. As students make observations, they should document what they observed.

- As a class, discuss what students observed, then draw a model on the board that depicts the phenomenon. (Light bounces off of an object, travels through the pinhole, and is visible—upside down—on the tracing paper inside the pinhole viewer.)

- Tell students that this is what happens with our eyes. Light bounces off objects, similar to the way in which it bounces off a mirror, and that light travels into the eye, enabling us to see the objects. We could see the book through the clear plastic wrap because the light that bounces off the object is able to travel through the transparent material and still reach our eyes. We could not see the book through the dark construction paper because the light that was bouncing off the object could not travel through the paper, so our eyes did not receive that light. Therefore, we did not see the book.

With guidance, as needed, have students draw models/diagrams of the pinhole viewer and the human eye, and have them describe what they observed.

Interdisciplinary Connections

ELA

Add audio recordings and visual displays to presentations when appropriate to enhance the development of main ideas or themes. (4-LS1-2),(4-LS4-2) **SL.4.5**

MATH

Model with mathematics. (4-PS4-2) **MP.4**

Draw points, lines, line segments, rays, angles (right, acute, obtuse), and perpendicular and parallel lines. Identify these in two-dimensional figures**. (4-PS4-2) 4.G.A.1**

Texts and Resources

NJ Model Curriculum Unit 4 - How Organisms Process Information

Pinhole Cameras and Eyes:

In this activity, students make a pinhole camera and see images formed on an internal screen. They then use a lens to see how this affects the images. Students investigate variables in its construction, and explore how it models the human eye's ability to receive and process information.

The Life of Environments

This unit is designed to address the concept that organisms sense the environment in order to live. It is a far-ranging and comprehensive unit that is designed to address multiple NGSS performance expectations (4-LS1-2, 4LS1-2, 4-PS3-2, 4-PS4-2) in seven explorative sections, with an additional summative assessment step.

Time to Think?

This resource allows the user to accurately measure and experiment with human reaction time. An interactive program measures reaction times in milliseconds and compares them in different cases (from simply reacting to a visual cue to having to read and then make a decision before reacting). This site provides a wide range of information and activities on the connection between the brain and behavior. Note: Link is to main introductory page. Scroll down to find links for the activity and others pages that allow users to view the results of other participants and guidance for conducting further research.

Catch It!

This lesson sequence involves student investigation of human reaction time and variables that may affect it. An intitial phase has students practice catching a dropped ruler and converting the distance it drops to the length of time it took to react. This provides an opportunity for data collection, graphing, and writing a conclusion. After this guided inquiry phase, students may conduct research on human senses and reaction time, or move on to designing their own investigations of the effects of variables of their choosing on their reaction times. *[NOTE - the link is to the CT Department of Education Science Curriculum page. Scroll to find that you can select Word, PDF, and Spanish versions of* *this resource under the title Grade 5 Embedded Task.]*

Teaching *NGSS* in K-5: Making Meaning through Discourse

The presenters were Carla Zembal-Saul, (Penn State University), Mary Starr, (Michigan Mathematics and Science Centers Network), and Kathy Renfrew (Vermont Agency of Education). After a brief introduction about the Next Generation Science Standards (*NGSS*), Zembal-Saul, Starr, and Renfrew gave context to the *NGSS* specifically for K-5 teachers, discussing three-dimensional learning, performance expectations, and background information on the *NGSS* framework for K-5. The presenters also gave a number of examples and tips on how to approach *NGSS* with students, and took participants' questions. The web seminar ended with the presentation of a number of recommended NSTA resources for participants to explore.

View the resource collection.

Continue discussing this topic in the community forums.

Evaluating Resources for *NGSS*: The EQuIP Rubric

The presenters were Brian J. Reiser, Professor of Learning Sciences in the School of Education and Social Policy at Northwestern University, and Joe Krajcik, Director of the CREATE for STEM Institute.

After a brief overview of the *NGSS,* Brian Reiser, Professor of Learning Sciences, School of Education at Northwestern University and Joe Krajcik, Director of CREATE for STEM Institute of Michigan State University introduced the Educators Evaluating Quality Instructional Products (EQuIP) Rubric. The web seminar focused on how explaining how the EQuIP rubric can be used to evaluate curriculum materials, including individual lessons, to determine alignment of the lesson and/or materials with the NGSS. Three-dimensional learning was defined, highlighted and discussed in relation to the rubric and the NGSS. An emphasis was placed on how to achieve the conceptual shifts expectations of NGSS and three-dimensional learning using the rubric as a guide. Links to the lesson plans presented and hard copies of materials discussed, including the EQuIP rubric, were provided to participants. The web seminar concluded with an overview of NSTA resources on the NGSS available to teachers by Ted, and a Q & A with Brian Reiser and Joe Krajcik.

View the resource collection.

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NGSS Crosscutting Concepts: Systems and System Models

The presenter was Ramon Lopez from the University of Texas at Arlington. Dr. Lopez began the presentation by discussing the importance of systems and system models as a crosscutting concept. He talked about the key features of a system: boundaries, components, and flows and interactions. Dr. Lopez also described different types of system models, including conceptual, mathematical, physical, and computational models. Participants discussed their current classroom applications of systems and system models and brainstormed ways to address challenges associated with teaching this crosscutting concept.

[*NGSS* Core Ideas: From Molecules to Organisms: Structures and Processes]

The presenters were Aaron Rogat of Educational Testing Service (ETS) and Barbara Hug of the University of Illinois at Urbana-Champaign. The program featured strategies for teaching about life science concepts that answer questions such as "How do the structures of organisms enable life's functions?" and "How do organisms grow and develop?"

Dr. Hug began the presentation by discussing the arrangement of life science core ideas within *NGSS* and comparing them to previous standards. Next, Dr. Rogat shared an example of a learning progression, showing how a concept can be taught from early elementary through high school. The presenters then talked about strategies for instruction and shared links to resources.

Visit the resource collection.

Continue discussing this topic in the community forums.

NGSS Core Ideas: Energy

The presenter was Jeff Nordine of the San Antonio Children's Museum. Ramon Lopez from the University of Texas at Arlington provided supporting remarks. The program featured strategies for teaching about physical science concepts that answer questions such as "How is energy transferred between objects or systems?" and "What is meant by conservation of energy?"

Dr. Nordine began the presentation by talking about the role of disciplinary core ideas within *NGSS* and the importance of energy as a core idea as well as a crosscutting concept. He then shared physicist Richard Feynman's definition of energy and related it to strategies for teaching about energy. Dr. Nordine talked about the elements of the energy core idea and discussed common student preconceptions.

Visit the resource collection.

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Grade 4, Science, Unit 5, Transfer of Energy

Content Area:	**Science**
Course(s):	**Science**
Time Period:	**January**
Length:	**4 weeks**
Status:	**Published**

Next Generation Science Standards

SCI.4-ESS3-1	Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.
SCI.4-PS3-2	Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.

Student Learning Objectives

- 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)
- Obtain and combine information from books and other reliable media to explain phenomena. (4-ESS3-1)
- Energy can be moved from place to place by moving objects or through sound, light, or electric currents. (4-PS3-2)
- 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)
- 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)
- 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)
- Energy can be transferred in various ways and between objects. (4-PS3-2)
- Cause and effect relationships are routinely identified and used to explain change. (4-ESS3-1)
- Knowledge of relevant scientific concepts and research findings is important in engineering. (4-ESS3-1)
- Over time, people’s needs and wants change, as do their demands for new and improved technologies.

(4-ESS3-1)

Enduring Understanding

Energy is necessary for change to occur in matter.

Energy can be stored, transferred and transformed, but cannot be destroyed.

Essential Questions

Where do we get the energy we need for modern life?

How does energy move?

From what natural resources are energy and fuels derived? In what ways does the human use of natural resources affect the environment?

How is energy transferred?

Assessment

Students who understand the concepts are able to:

- Make observations to produce data that can serve as the basis for evidence for an explanation of a phenomenon or for a test of a design solution.

Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.

Students who understand the concepts are able to:

- Identify cause-and-effect relationships in order to explain change.
- Obtain and combine information from books and other reliable media to explain phenomena.
- Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.

Examples of renewable energy resources could include:

- Wind energy
- Water behind dams
- Sunlight

Examples of nonrenewable energy resources are:

- Fossil fuels
- Fossil materials
-
- Examples of environmental effects could include:
- Loss of habitat due to dams
- Loss of habitat due to surface mining
- Air pollution from burning of fossil fuels.

Instructional Activities

Students conduct investigations to observe that energy can be transferred from place to place by sound, light, heat, and electrical currents. They describe that energy and fuels are derived from natural resources and that their uses affect the environment. Throughout this unit, students obtain, evaluate, and communicate information as they examine cause-and-effect relationships between energy and matter.

To begin the unit of study's progression of learning, students need opportunities to observe the transfer of heat energy. They can conduct simple investigations, using thermometers to measure changes in temperature as heat energy is transferred from a warmer object to a colder one. For example, hot water can be poured into a large Styrofoam cup, and then a smaller plastic cup of cold water can be placed inside the larger cup of water. A thermometer can be placed in each cup, and students can observe and record changes in the temperature of the water in each cup every minute over the course of about 10–15 minutes, or until the temperatures are the same. Students can use their data as evidence to explain that some of the heat energy from the hot water transferred to the cold water. This transfer of heat caused the cold water to become gradually warmer and the hot water to cool. This process continued until the cups of water reached the same temperature.

Students can also place a thermometer in the palm of their hands, close their hands around it, and measure the temperature. They can then place a piece or two of ice into their palms and close their fists around the ice until it melts. When they again measure the temperature of their palms, they will observe a change. Students can use these data to describe how some of the heat from their hands transferred to the ice, causing it to melt, while the ice also decreased the temperature of their hand. It is important that students understand that heat is transferred from warmer to colder objects. When an object cools, it loses heat energy. When an object gets warmer, it gains heat energy.

To continue learning about energy transfer, students can build simple electric circuits. As students work in small groups to build circuits, they should add a bulb and/or a buzzer to the circuit in order to observe and describe the ways in which energy is transferred in the circuit. (The word "transfer" can refer to a change in the type of energy or a change in the location of energy.) For example, stored energy in a battery is transferred into electrical energy, which is then transferred into light energy if a bulb is added to the circuit. The energy transfers from the battery to the wire and then to the bulb. The same holds true if a buzzer is added to the circuit. The stored energy in the battery is transferred into electrical energy, which is then transferred into sound energy. (Keep in mind that energy is not actually produced. When we say that energy is "produced," this typically refers to the conversion of stored energy into a desired form for practical use. Students should be encouraged to use the term "transferred" rather than "produced").

After conducting these types of investigations, the class can create a list of events in which energy is transferred. For example, when a ball is thrown against a wall, some of the motion energy is transferred to sound energy; when water boils on the stove top, heat energy from the stove is transferred to the pot and to the water in the pot; and when a doorbell is rung, electrical energy is transferred into sound energy.

Next, students learn about fuels and energy, and conduct research using books and other reliable media to determine which natural resources are sources of energy. Light, heat, sound, and electricity are all forms of energy. Energy is not matter. Fuels, however, are matter. For example, fossil fuels, such as coal, oil, and natural gas, are matter. When fossil fuels are burned, energy stored in the fuel can be transferred from stored energy to heat, light, electrical, and/or motion energy. Therefore, fuels are considered to be a source of energy.

Energy can also be obtained from other sources, such as wind, water, and sunlight. Air and water are both matter, but when they are moving, they have motion energy. Energy from wind (moving air) and from moving water can be transferred into electrical energy. Light energy from the sun can also be transferred to heat energy or electrical energy. In addition, energy can be released through nuclear fission using materials known as fissile materials.

As students learn about fuels and other sources of energy, they should determine which sources are renewable and which are nonrenewable. Generally, a fuel or source of energy is considered nonrenewable if that source is limited in supply and cannot be replenished by natural means within a reasonable amount of time. Renewable sources of energy are those that are replenished constantly by natural means. Using this general description, all fossil fuels are considered nonrenewable, because these resources were naturally created over millions of years. Fissile materials are also nonrenewable. On the other hand, wind, moving water, and sunlight are renewable sources of energy.

As the population continues to grow, so does the demand for energy. Human use of natural resources for energy, however, has multiple effects on the environment. Students should conduct further research to determine how the use of renewable and nonrenewable resources affects the environment. Some examples include:

- Changes in and loss of natural habitat due to the building of dams and the change in the flow of water;
- Changes in and loss of natural habitat due to surface mining; and air pollution caused by the burning of fossil fuels in factories, cars, and homes.

As students conduct research and gather information from a variety of reliable resources, they can take notes and use the information to describe and explain the impact that human use of natural resources has on the environment.

Interdisciplinary Connections

ELA

Conduct short research projects that build knowledge through investigation of different aspects of a topic. (4-PS3-2),(4-ESS3-1) **W.4.7**

Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources. (4-PS3-2),(4-ESS3-1) **W.4.8**

Draw evidence from literary or informational texts to support analysis, reflection, and research. (4-ESS3-1) **W.4.9**

MATH

Reason abstractly and quantitatively. (4-ESS3-1) **MP.2**

Model with mathematics. (4-ESS3-1) **MP.4**

Interpret a multiplication equation as a comparison, e.g., interpret 35 = 5 × 7 as a statement that 35 is 5 times as many as 7 and 7 times as many as 5. Represent verbal statements of multiplicative comparisons as multiplication equations. (4-ESS3-1) **4.OA.A.1**

Texts and Resources

NJ Model Curriculum Unit 5 - Transfer of Energy

Switch Energy Project: The Educator Portal provides free access to a documentary, energy labs, videos, and study guides.
Wind Generator: Windmills have been used for hundreds of years to collect energy from the wind in order to pump water, grind grain, and more recently generate electricity. There are many possible designs for the blades of a wind generator and engineers are always trying new ones. Design and test your own wind generator, then try to improve it by running a small electric motor connected to a voltage sensor.

Thermal Energy Transfer: Explore the three methods of thermal energy transfer: conduction, convection, and radiation, in this interactive from WGBH, through animations and real-life examples in Earth and space science, physical science, life science, and technology.

Assessment for the Next Generation Science Standards

The presenters were Joan Herman, Co-Director Emeritus of the National Center for Research on Evaluation, Standards, and Student Testing (CRESST) at UCLA; and Nancy Butler Songer, Professor of Science Education and Learning Technologies, University of Michigan.

Dr. Herman began the presentation by summarizing a report by the National Research Council on assessment for the Next Generation Science Standards (NGSS). She talked about the development of the report and shared key findings. Next, Dr. Songer discussed challenges for classroom implementation and provided examples of tasks that can be used with students to assess their proficiency on the NGSS performance expectations.

View the resource collection.

Continue discussing this topic in the community forums.

***NGSS* Crosscutting Concepts: Patterns**

The presenter was Kristin Gunckel from the University of Arizona. Dr. Gunckel began the presentation by discussing how patterns fit in with experiences and explanations to make up scientific inquiry. Then she talked about the role of patterns in NGSS and showed how the crosscutting concept of patterns progresses across grade bands. After participants shared their ideas about using patterns in their own classrooms, Dr. Gunckel shared instructional examples from the elementary, middle school, and high school levels.

NGSS Crosscutting Concepts: Structure and Function

The presenters were Cindy Hmelo-Silver and Rebecca Jordan from Rutgers University. Dr. Hmelo-Silver and Dr. Jordan began the presentation by discussing the role of the crosscutting concept of structure and function within NGSS. They then asked participants to think about the example of a sponge and discuss in the chat how a sponge's structure relates to its function. The presenters introduced the Structure-Behavior-Function (SBF) theory and talked about the importance of examining the relationships between mechanisms and structures. They also discussed the use of models to explore these concepts.

NGSS Core Ideas: Energy

The presenter was Jeff Nordine of the San Antonio Children's Museum. Ramon Lopez from the University of Texas at Arlington provided supporting remarks. The program featured strategies for teaching about physical science concepts that answer questions such as "How is energy transferred between objects or systems?" and "What is meant by conservation of energy?"

Dr. Nordine began the presentation by talking about the role of disciplinary core ideas within *NGSS* and the importance of energy as a core idea as well as a crosscutting concept. He then shared physicist Richard Feynman's definition of energy and related it to strategies for teaching about energy. Dr. Nordine talked about the elements of the energy core idea and discussed common student preconceptions.

Visit the resource collection.
Continue discussing this topic in the community forums.

Grade 4, Science, Unit 6, Force and Motion

Content Area:	**Science**
Course(s):	**Science**
Time Period:	**February**
Length:	**4 weeks**
Status:	**Published**

Next Generation Science Standards

SCI.4-PS3-1	Use evidence to construct an explanation relating the speed of an object to the energy of that object.
SCI.4-PS3-3	Ask questions and predict outcomes about the changes in energy that occur when objects collide.

Student Learning Objectives

-

- 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)
- Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships. (4-PS3-3)
- Use evidence (e.g., measurements, observations, patterns) to construct an explanation. (4-PS3-1)
- 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-PS3-3)
- 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-PS3-3)
- When objects collide, the contact forces transfer energy so as to change the objects' motions. (4-PS3-3)
- Energy can be transferred in various ways and between objects. (4-PS3-1) (4-PS3-3)

Enduring Understanding

Energy is necessary for change to occur in matter.

The same basic rules govern the motion of all bodies, from planets and stars to birds and billiard balls.

Essential Questions

What is energy and how does it relate to motion?

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

In what ways does energy change when objects collide?

Assessment

Students who understand the concepts are able to:

- Describe various ways that energy can be transferred between objects.
- Use evidence (e.g., measurements, observations, patterns) to construct an explanation.

Use evidence to construct an explanation relating the speed of an object to the energy of that object. *(Assessment does not include quantitative measures of changes in the speed of an object or on any precise or quantitative definition of energy.)*

Students who understand the concepts are able to:

- Describe the various ways that energy can be transferred between objects.
- Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships.

Ask questions and predict outcomes about the changes in energy that occur when objects collide. Emphasis is on the change in the energy due to the change in speed, not on the forces, as objects interact. *(Assessment does not include quantitative measurements of energy.)*

Instructional Activities

In order to understand and explain the relationship between an object's speed and its energy, students need multiple opportunities to observe objects in motion. Students can roll balls down ramps, build and race rubber band cars, or build roller coasters. As they observe the motion of objects, they should collect data about the relative speed of objects in relation to the strength of the force applied to them. For example, when a ball is placed at the top of a ramp, it has stored energy, due to the force of gravity acting on it. When the ball is released, that stored energy is changed (transferred) into motion energy. Increasing the height of a ramp also increases the amount of stored energy in the ball at the top of the ramp. If the ball is released from a higher starting point, it rolls faster and farther. Likewise, winding the rubber band in a rubber band car stores energy in the rubber band, which is then changed, or transferred, into motion energy (kinetic) as the car moves forward. The more times you wind the rubber band, the greater the amount of stored energy in the rubber band, and the farther and faster the car goes. As students investigate these types of force and motion systems, they should conduct multiple trials, increasing and decreasing the amount of energy, then collect qualitative data as they observe the impact differing amounts of energy have on the relative speed of the object in motion. Students should then use their data as evidence to support their explanation of the relationship between the relative speed of an object and its energy.

Once students understand that the faster an object moves, the more energy it possesses, they can begin to explore ways in which energy can be transferred. As they investigated the relationship between speed and energy, students learned that stored energy was changed, or transferred, into motion energy. To broaden their understanding of energy transfer, students should be provided with opportunities to observe objects colliding and should be encouraged to ask questions that lead to further investigation. For example, if students roll a ball towards a wall, or roll two balls so that they collide, they may observe any or all of the following:

- Change(s) in the direction of motion
- Change(s) in speed
- Change(s) in the type of energy (e.g., motion energy to sound energy, sound energy to heat energy)
- Change(s) in the type of motion (rolling to bouncing).

As students continue to investigate interactions between moving objects, they should notice that when a moving object collides with a stationary object, some of the motion energy of one is transferred to the other. In addition, some of the motion energy is changed, or transferred to the surrounding air, and as a result, the air gets heated and sound is produced. Likewise, when two moving objects collide, they transfer motion energy to one another and to the surrounding environment as sound and heat. It is important that as students observe these types of interactions, they collect observational data, document the types of changes they observe, look for patterns of change in both the motion of objects and in the types of energy transfers that occur, and make predictions about the future motion of objects. Their investigations will help them understand that:

- Energy can be transferred in various ways and between objects.
- Energy is present whenever there are moving objects.
- Energy can be moved, or transferred, from place to place by moving objects.

When objects collide, some energy may be changed or transferred into other types of energy.

Interdisciplinary Connections

ELA

Refer to details and examples in a text when explaining what the text says explicitly and when drawing inferences from the text. (4-PS3-1) **RI.4.1**

Explain events, procedures, ideas, or concepts in a historical, scientific, or technical text, including what happened and why, based on specific information in the text. (4-PS3-1) **RI.4.3**

Integrate information from two texts on the same topic in order to write or speak about the subject knowledgeably. (4-PS3-1) **RI.4.9**

Write informative/explanatory texts to examine a topic and convey ideas and information clearly. (4-PS3-1) **W.4.2**

Conduct short research projects that build knowledge through investigation of different aspects of a topic. (4-PS3-3) **W.4.7**

Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources. (4-PS3-1),(4-PS3-3) **W.4.8**

Draw evidence from literary or informational texts to support analysis, reflection, and research. (4-PS3-1) **W.4.9**

Texts and Resources

NJ Model Curriculum Unit 6 - Force and Motion

NGSS Crosscutting Concepts: Stability and Change

The presenter was Brett Moulding, director of the Partnership for Effective Science Teaching and Learning. Mr. Moulding began the web seminar by defining stability and change and discussing the inclusion of this concept in previous standards documents such as the National Science Education Standards (NSES). Participants brainstormed examples of science phenomena that can be explained by using the concept of stability and change. Some of their ideas included Earth's orbit around the Sun, carrying capacity of ecosystems, and replication of DNA. Mr. Moulding then discussed the role of stability and change within NGSS. Participants again shared their ideas in the chat, providing their thoughts about classroom implementation of this crosscutting concept.

NGSS **Core Ideas: Energy**

The presenter was Jeff Nordine of the San Antonio Children's Museum. Ramon Lopez from the University of Texas at Arlington provided supporting remarks. The program featured strategies for teaching about physical science concepts that answer questions such as "How is energy transferred between objects or systems?" and "What is meant by conservation of energy?"

Dr. Nordine began the presentation by talking about the role of disciplinary core ideas within *NGSS* and the importance of energy as a core idea as well as a crosscutting concept. He then shared physicist Richard Feynman's definition of energy and related it to strategies for teaching about energy. Dr. Nordine talked about the elements of the energy core idea and discussed common student preconceptions.

Visit the resource collection.
Continue discussing this topic in the community forums.

Spool Racers: This resource includes three parts: a video clip from the TV show, Zoom, to introduce the activity, an essay with background information about energy, and a set of printable instructions. Students use a spool, a toothpick, a washer, a rubber band, and a pencil to build a racer. They conduct tests with the racer by varying the number of twists in the rubber band or changing other design features. These websites provide additional ideas for modifying the basic rubber band racer design: http://www.scienceworld.ca/resources/activities/popcan-porsche and http://pbskids.org/designsquad/build/rubber-band-car/.

Force and Motion: This video segment from IdahoPTV's D4K defines gravity, force, friction and inertia through examples from amusement park rides. Examples and explanations of Sir Isaac Newton's Three Laws of Motion are also included.

Advanced High-Powered Rockets: Students select a flight mission (what they want the rocket to do) and design and construct a high-power paper rocket that will achieve the mission. They construct their rocket, predict its performance, fly the rocket, and file a post-flight mission report. Missions include achieving high altitude records, landing on a "planetary" target, carrying payloads, testing a rocket recovery system, and more.

Grade 4, Science, Unit 7, Using Engineering Design with Force and Motion Systems

Content Area:	**Science**
Course(s):	**Science**
Time Period:	**April**
Length:	**5 weeks**
Status:	**Published**

Next Generation Science Standards

SCI.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.
SCI.4-PS3-4	Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.
SCI.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.
SCI.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.

Student Learning Objectives

- 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 problem. (3-5-ETS1-2)
- 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)
- 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)
- 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-PS3-4)
- When objects collide, the contact forces transfer energy so as to change the object's' motions. (4-PS3-3)
- The expression “produce energy” typically refers to the conversion of stored energy into a desired form for practical use. (4-PS3-4)
- 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)

- Research on a problem 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)
- 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)
- Energy can be transferred in various ways and between objects. (4-PS3-4)
- Engineers improve existing technologies or develop new ones. (4-PS3-4)
- Most scientists and engineers work in teams. (4-PS3-4)
- Science affects everyday life. (4-PS3-4)
- People's needs and wants change over time, as do their demands for new and improved technologies. (3-5-ETS1-1)
- Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands. (3-5-ETS1-2)

Enduring Understanding

Engaging in the practices of science helps students understand how scientific knowledge develops. Likewise, engaging in the practices of engineering helps students understand the work of engineers as well as the links between engineering and science.

Essential Questions

How can scientific ideas be applied to design, test, and refine a device that converts energy from one form to another?

How can energy be used to solve a problem?

Assessment

Students who understand the concepts are able to:

- Describe the various ways that energy can be transferred between objects.
- Apply scientific ideas to solve design problems.
- Apply scientific ideas to design, test, and refine a device that converts energy from one form to another. (Devices should be limited to those that convert motion energy to electric energy or use stored energy to cause motion or produce light or sound.)
- Examples of devices could include electric circuits that convert electrical energy into motion energy of a vehicle, light, or sound or passive solar heater that converts light into heat. Examples of constraints could include the materials, cost, or time to design the device.
- 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.
- Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
- Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design problem.
- 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.
- 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.

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.

Instructional Activities

Note: In the prior unit of study, students observed objects in motion in order to understand the relationship between the speed of an object and its energy, and they investigated the transfer of energy from one object to another, as well as from one form to another. In this unit, students will apply scientific ideas about force, motion, and energy in order to design, test, and refine a device that converts energy from one form to another. Through this process, students will learn that science affects everyday life and that engineers often work in teams, using scientific ideas, in order to meet people's needs for new or improved technologies.

To begin the **engineering design process**, students must be presented with the problem of designing a device that converts energy from one form to another. This process should include the following steps:

As a class, students should create a list of all the concepts that they have learned about force, motion, and energy.

- The faster a given object is moving, the more energy it possesses.
- Energy is present whenever there are moving objects, sound, light, or heat.
- Energy can be transferred in various ways and between objects.
- Energy can be moved from place to place by moving objects or through sound, light, or electric currents.
- 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.
- When objects collide, the contact forces transfer energy so as to change the object's' motions.

Have students brainstorm examples of simple devices that convert energy from one form to another. As students give examples, the teacher should draw one or two and have students describe how each device converts energy from one form to another.

Next, the teacher can present a "Design Challenge" to students: Design and build a simple device that converts energy from one form to another. Please note that teachers should limit the devices to those that convert motion energy to electric energy or that use stored energy to cause motion or produce light or sound.

Small groups of students should conduct research, using several sources of information, to build understanding of "stored energy." Students can look for examples of objects that have stored energy. Stretched rubber bands, compressed springs, wound or twisted rubber bands, batteries, wind-up toys, and objects at the top of a ramp or held at a height above the ground all have stored energy.

As a class, determine criteria and possible constraints on the design solutions. For example, devices are only required to perform a single energy conversion (i.e., transfer energy from one form to another), and devices must transfer stored energy to motion, light, or sound. Constraints could include the use of

Interdisciplinary Connections

ELA

Students conduct research that builds their understanding of energy transfers. They will gather relevant information from their investigations and from multiple print or digital sources, take notes, and categorize their findings. They should use this information to construct explanations and support their thinking.

MATH

Students can:

- Solve multistep word problems, using the four operations.
- Represent these problems using equations with a letter standing for the unknown quantity.
- Assess the reasonableness of answers using mental computation and estimating strategies, including rounding.

For example, "The class has 144 rubber bands with which to make rubber band cars. If each car uses 6 rubber bands, how many cars can be made? If there are 28 students in the class, how many rubber bands can each car have (if every car has the same number of rubber bands)?"

Students can also analyze constraints on materials, time, or cost to determine what implications the constraints have for design solutions. For example, if a design calls for 20 screws and screws are sold in boxes of 150, how many copies of the design can be made?

Texts and Resources

NJ Model Curriculum Unit 7 - Using Engineering Design with Force and Motion Systems

The Sound of Science: Students are given a scenario/problem that needs to be solved: Their school is on a field trip to the city to listen to a rock band concert. After arriving at the concert, the students find out that the band's instruments were damaged during travel. The band needs help to design and build a stringed instrument with the available materials, satisfying the following criteria and constraints: 1) Produce three different pitched sounds. 2) Include at least one string. 3) Use only available materials. 4) Be no longer than 30 cm / 1 foot. The challenge is divided into 4 activities. Each activity is designed to build on students' understanding of the characteristics and properties of sound. By using what they learn about sound from these activities, students are then encouraged to apply what they know about sound to complete the engineering design challenge.

Energy Makes Things Happen: The Boy Who Harnessed the Wind: This article from Science and Children provides ideas for using the trade book, The Boy Who Harnessed the Wind, as a foundation for a lesson on generators. This beautiful book is the inspiring true story of a teenager in Malawi who built a generator from found materials to create much-needed electricity. The lesson allows students to explore the concept of energy transfer using crank generators. Students then design improvements to the crank mechanism on the generator. The lesson may be extended by having students build their own generators.

Light Your Way: Using the engineering design process, students will be designing and building a lantern that they will hypothetically be taking with them as they explore a newly discovered cave. The criteria of the completed lantern will include: hands need to be free for climbing, the lantern must have an on/off switch, it must point ahead when they are walking so they can see in the dark, and the lantern must be able to stay lit for at least 15 minutes. The constraints of the activity will be limited materials with which to build. At the completion of the activity, the students will present their final lantern to the class explaining how they revised and adapted the lantern to meet the criteria of the project. Students will include in the presentation the sketch of the model they created prior to building showing the labeled circuit they designed. This activity was one of numerous engineering lessons from the Virginia Children's Engineering Council geared towards Grades 1-5. http://www.childrensengineering.org/technology/designbriefs.php.

NGSS Appendix I – Appendix I provides an explanation how engineering is treated in the NGSS. Engineering Design in the NGSS The Next Generation Science Standards (NGSS) represent a commitment to integrate engineering design into the structure of science education by raising engineering design to the same level as scientific inquiry when teaching science disciplines at all levels, from kindergarten to grade 12.

***NGSS* Crosscutting Concepts: Energy and Matter—Flows, Cycles, and Conservation**

The presenters were Charles W. (Andy) Anderson and Joyce Parker from Michigan State University. Dr. Anderson and Dr. Parker began the web seminar by discussing the role of energy and matter as a crosscutting concept. They talked about energy and matter at different scales, from the atomic to the macroscopic. The presenters shared information about how students learn about this crosscutting concept and how to address preconceptions. They then described instructional strategies such as modeling that can help students better understand the flow of energy and matter.

***NGSS* Crosscutting Concepts: Scale, Proportion, and Quantity**

The presenters were Amy Taylor and Kelly Riedinger from the University of North Carolina Wilmington. Dr. Taylor began the presentation by discussing the definition of scale. Next, Dr. Riedinger talked about the role of scale, proportion, and quantity in NGSS. Participants shared their own experiences teaching about scale in the classroom before the presenters described additional instructional strategies that can provide students with a real-world understanding of this crosscutting concept. Dr. Taylor and Dr. Riedinger showed examples of activities from elementary, middle, and high school. They shared video clips and other resources that can help educators build their capacity for teaching about scale.

Grade 4, Science, Unit 8, Waves and Information

Content Area:	**Science**
Course(s):	**Science**
Time Period:	**May**
Length:	**4 weeks**
Status:	**Published**

Next Generation Science Standards

SCI.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.
SCI.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.
SCI.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.
SCI.4-PS4-3	Generate and compare multiple solutions that use patterns to transfer information.

Student Learning Objectives

- Develop a model using an analogy, example, or abstract representation to describe a scientific principle. (4-PS4-1)
- 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)
- 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)
- Science findings are based on recognizing patterns. (4-PS4-1)
- 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)
- 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)
- 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)

- Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. *(secondary to 4-PS4-3)*
- Research on a problem 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)
- 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)

Enduring Understanding

Waves are regular patterns of motion that can move objects and transfer energy.

Waves of the same type can differ in amplitude and wave-length.

Essential Questions

If a beach ball lands in the surf, beyond the breakers, what will happen to it?

Which team can design a way to use patterns to communicate with someone across the room?

How can we use waves to gather and transmit information?

Assessment

Students who understand the concepts can:

- Sort and classify natural phenomena using similarities and differences in patterns.
- Develop a model using an analogy, example, or abstract representation to describe a scientific principle.

Develop a model (e.g., diagram, analogy, or physical model) of waves to describe patterns in terms of amplitude and wavelength, and that waves can cause objects to move. *(Assessment does not include interference effects, electromagnetic waves, non-periodic waves, or quantitative models of amplitude and wavelength).*

Students who understand the concepts can:

- Sort and classify designed products using similarities and differences in patterns.
- Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution.
- 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.
- Generate and compare multiple solutions that use patterns to transfer information. Examples of solutions could include:

Drums sending coded information through sound waves;

Using a grid of ones and zeroes representing black and white to send information about a picture;

Using Morse code to send text.

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

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.

Instructional Activities

In this unit of study, students plan and carry out investigations, analyze and interpret data, and construct explanations. They also develop and use models to describe patterns of waves in terms of amplitude and wavelength and to show that waves can cause objects to move.

Waves, which are regular patterns of motion, can differ in amplitude (height of the wave) and wavelength (spacing between wave peaks). Students can model the properties of waves by disturbing the surface of water in a variety of pans and buckets. Students should make observations as they strike the surface of the water with small and large objects, such as marbles and rocks. In addition, smaller pans can be tilted in different directions in order to observe the effect on the wave patterns created on the surface of the water. Students should observe and describe a number of similarities and differences in the wave patterns created, including the following:

- When an object hits the surface of water, waves move across the surface.
- Waves move up and down across the surface of the water away from the point of contact.
- Waves on the surface of the water move away from the point of contact in increasingly larger circles.
- When waves hit another surface, the waves change direction and move away from the surface with which they come into contact.
- The height of the wave (amplitude) and the distance between the peaks of waves (wavelength) varies depending upon the intensity of the disturbance, and/or the size (mass, volume) of the object disturbing the surface of the water.

When describing the properties of waves, students should also develop a model using drawings, diagrams, or physical models (such as a slinky or jump rope) to show the basic properties of waves (amplitude and wavelength). In addition, the class should discuss other real-world examples of waves, including sound and light waves, using understandings developed in prior units of study.

To begin the engineering design process, students are challenged to design a way to use patterns to transfer information. This process should include the following steps:

- As a class, brainstorm a list of ways in which patterns have been used in the past to communicate over distance. Some examples include the use of smoke signals, drums, and Morse code on a telegraph.
- Small groups collaboratively conduct research to determine other possible ways of communicating using patterns over distances.
- As a class, determine criteria and possible constraints on the design solutions.

Criteria might include that groups must communicate information using patterns, the design solution must communicate over a predetermined distance, and groups must be able to describe how patterns were used in the design to communicate over a distance.

Possible constraints might include materials available to build/create a device and the amount of time available to design and build.

- Small groups work collaboratively to design and build a device or design a process for communicating information over a distance. Some examples could include:

Drums sending coded information through sound waves.

Use a flashlight to convey information using a pattern of on and off.

Use Morse code to send information.

Build an instrument with a box and rubber bands of varying sizes that can be plucked in a pattern to communicate information.

Use musical patterns on a xylophone or tuning forks to convey information.

Use string and cups to build a simple “phone” to send information.

- After small groups finish designing and building, they should put together a presentation that includes a written description/explanation of how patterns are used to communicate information. They can also include pictures, video or audio recordings, and/or models to support their explanation.

- Each group presents their design solution to the class. After observing each design solution, students should classify each based on the type or types of patterns used to communicate (e.g., sound, light, or both).

- Students investigate how well the solutions perform under a range of likely conditions (e.g., environmental noise or light, increases in distance). This may involve additional research, planning and conducting multiple investigations to produce data, and collecting and analyzing additional data that can be used as evidence to support conclusions. All tests that are planned and carried out should be fair tests in which variables are controlled and failure points are considered in order to identify elements of the design solution that do and do not meet criteria and constraints.

- Students compare the solutions, determining which can be used to successfully communicate information over a distance using patterns. Students should determine how well each design solution meets criteria, using data as evidence to support their thinking.

Throughout this process, communicating with peers is important, and can lead to better designs. After completing the engineering design process, students should discuss ways in which we use patterns in today’s technology to communicate over long distances and how engineers have improved existing technologies over time in order to increase benefits, decrease known risks, and meet societal demands.

Integration of engineering-

Engineering design is an integral part of this unit of study. Students are expected to research a problem and communicate proposed solutions to others; define a simple design problem including specified criteria for success and constraints on materials time, or cost; and plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of the design solution that can be improved. This process is outlined in greater detail in the previous section.

Interdisciplinary Connections

ELA

Integrate information from two texts on the same topic in order to write or speak about the subject knowledgeably. (4-PS4-3) **RI.4.9**

Add audio recordings and visual displays to presentations when appropriate to enhance the development of main ideas or themes. *(4-PS4-1)* **SL.4.5**

Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently. (3-5-ETS1-2) **RI.5.1**

Integrate information from several texts on the same topic in order to write or speak about the subject knowledgeably. (3-5-ETS1-2) **RI.5.9**

Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic. (3-5-ETS1-3) **W.5.7**

Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources. (3-5-ETS1-3) **W.5.8**

Draw evidence from literary or informational texts to support analysis, reflection, and research. (3-5-ETS1-3) **W.5.9**

MATH

Reason abstractly and quantitatively. (3-5-ETS1-2),(3-5-ETS1-3) **MP.2**

Model with mathematics. *(4-PS4-2),*(3-5-ETS1-2),(3-5-ETS1-3) **MP.4**

Use appropriate tools strategically. (3-5-ETS1-2),(3-5-ETS1-3) **MP.5**

Operations and Algebraic Thinking (3-ETS1-2) **3-5.OA**

Draw points, lines, line segments, rays, angles (right, acute, obtuse), and perpendicular and parallel lines. Identify these in two-dimensional figures. *(4-PS4-2)* **4.G.A.1**

Texts and Resources

NJ Model Curriculum Unit 8 - Waves and Information

'hat it Looks Like in the Classroom" section of this document describes several student sense-making and engineering ta

ah Education Network has created several resources for fourth grade science teachers.

Michigan NGSS Moodle: The purpose of this website to provide K-5 Science teachers with resources, lessons, and activities based on the NGSS which were created by teachers in our region.

NSTA Web Seminar: *NGSS Core Ideas: Waves and Their Applications in Technologies for Information Transfer, September 24, 2013*

Ramon Lopez from the University of Texas at Arlington is the presenter of this web seminar. The program featured strategies for teaching about physical science concepts that answer questions such as "How are waves used to transfer energy and information?" and "How are instruments that transmit and detect waves used to extend human senses?"

The web seminar is available at: http://learningcenter.nsta.org/resource/?id=10.2505/9/WSNGSS13_Oct22

NSTA Web Seminar: Teaching *NGSS* in K-5: Making Meaning through Discourse

Zembal-Saul, Starr, and Renfrew gave context to the *NGSS* specifically for K-5 teachers, discussing three-dimensional learning, performance expectations, and background information on the *NGSS* framework for K-5. The presenters also gave a number of examples and tips on how to approach *NGSS* with students, and took participants' questions. The web seminar ended with the presentation of a number of recommended NSTA resources for participants to explore.

The web seminar is available at:
http://learningcenter.nsta.org/products/symposia_seminars/NGSS/webseminar50.aspx

NSTA Web Seminar: *Teaching NGSS in Elementary School—Fourth Grade*

The web seminar began with an introduction to NGSS, its framework for K-12 science education, and its cross-cutting concepts and core ideas by NSTA's Ted Willard. Mary Starr and Kathy Renfrew began with a look into disciplinary core ideas, using the example of energy, and how they apply to the fourth grade in terms of performance expectations and an approach to science and engineering practices. Kathy also brought a special guest with her, Tracy Lavallee, a teacher from Vermont featured in the web seminar's videos. Using two videos taken from Tracy's fourth grade classroom, lesson plan ideas and approaches were discussed and teachers were able to share their thoughts and approaches on the classroom activities. A number of NSTA Learning Center tools and resources were shared as well a number of website links for further investigation.
This web seminar is available at:
https://learningcenter.nsta.org/products/symposia_seminars/NGSS/webseminar47.aspx.