Grade 4 Science, Unit 2

Earth Processes

Overview

Unit abstract

In this unit of study, students apply their knowledge of natural Earth processes to generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans. In order to describe patterns of Earth's features, students analyze and interpret data from maps. The crosscutting concepts of patterns, cause and effect, and the influence of engineering, technology, and science on society and the natural world are called out as organizing concepts for these disciplinary core ideas. In the fourth grade performance expectations, students are expected to demonstrate grade-appropriate proficiency in planning and carrying out investigations, analyzing and interpreting data, and constructing explanations and designing solutions. Students are expected to use these practices to demonstrate understanding of the core ideas.

Essential question

- What patterns of Earth's features can be determined with the use of maps?

Written Curriculum

Next Generation Science Standards

4. Earth's Systems: Processes that Shape the Earth

Students who demonstrate understanding can:

4-ESS2-2. Analyze and interpret data from maps to describe patterns of Earth's features. [Clarification Statement: Maps can include topographic maps of Earth's land and ocean floor, as well as maps of the locations of mountains, continental boundaries, volcanoes, and earthquakes.]

The performance expectations above were developed using the following elements from the NRC document: *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data Analyzing data in 3–5 builds on K–2 experiences and progresses to introducing quantitative approaches to collecting data and conducting multiple trials of qualitative observations. When possible and feasible, digital tools should be used. ▪ Analyze and interpret data to make sense of phenomena using logical reasoning. (4-ESS2-2)	**ESS2.B: Plate Tectonics and Large-Scale System Interactions** ▪ The locations of mountain ranges, deep ocean trenches, ocean floor structures, earthquakes, and volcanoes occur in patterns. Most earthquakes and volcanoes occur in bands that are often along the boundaries between continents and oceans. Major mountain chains form inside continents or near their edges. Maps can help locate the different land and water features areas of Earth. (4-ESS2-2)	**Patterns** ▪ Patterns can be used as evidence to support an explanation. (4-ESS2-2)

Connections to other DCIs in fourth grade: N/A

Articulation of DCIs across grade-levels: **2.ESS2.B** (4-ESS2-2); **2.ESS2.C** (4-ESS2-2); **5.ESS2.C** (4-ESS2-2); **MS.ESS1.C** (4-ESS2-2); **MS.ESS2.A** (4-ESS2-2); **MS.ESS2.B** (4-ESS2-2)

Common Core State Standards Connections:

ELA/Literacy –

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 explains how the information contributes to an understanding of the text in which it appears. (4-ESS2-2)

Mathematics –

4.MD.A.2 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. Earth's Systems: Processes that Shape the Earth

Students who demonstrate understanding can:

4-ESS3-2. Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans. * [Clarification Statement: Examples of solutions could include designing an earthquake resistant building and improving monitoring of volcanic activity.] [Assessment Boundary: Assessment is limited to earthquakes, floods, tsunamis, and volcanic eruptions.]

The performance expectations above were developed using the following elements from the NRC document: *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 3–5 builds on K–2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems. ▪ Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution. (4-ESS3-2)	**ESS3.B: Natural Hazards** ▪ A variety of hazards result from natural processes (e.g., earthquakes, tsunamis, volcanic eruptions). Humans cannot eliminate the hazards but can take steps to reduce their impacts. (4-ESS3-2) *(Note: This Disciplinary Core Idea can also be found in 3.WC.)* **ETS1.B: Designing Solutions to Engineering Problems** ▪ Testing a solution involves investigating how well it performs under a range of likely conditions. *(secondary to 4-ESS3-2)*	**Cause and Effect** ▪ Cause and effect relationships are routinely identified, tested, and used to explain change. (4-ESS3-2) ------------------------------------ ***Connections to Engineering, Technology, and Applications of Science*** **Influence of Engineering, Technology, and Science on Society and the Natural World** ▪ Engineers improve existing technologies or develop new ones to increase their benefits, to decrease known risks, and to meet societal demands. (4-ESS3-2)

Connections to other DCIs in fourth grade: **4.ETS1.C** (4-ESS3-2)

Articulation of DCIs across grade-levels: **K.ETS1.A** (4-ESS3-2); **2.ETS1.B** (4-ESS3-2); **2.ETS1.C** (4-ESS3-2); **MS.ESS2.A** (4-ESS3-2); **MS.ESS3.B** (4-ESS3-2); **MS.ETS1.B** (4-ESS3-2)

Common Core State Standards Connections:

ELA/Literacy –

RI.4.1 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.4.9 Integrate information from two texts on the same topic in order to write or speak about the subject knowledgeably. (4-ESS3-2)

Mathematics –

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

MP.4 Model with mathematics. *(4-ESS3-2)*

4.OA.A.1 Interpret a multiplication equation as a comparison, e.g., interpret $35 = 5 \times 7$ 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)*

<table>
<tr><td colspan="3">3-5. Engineering Design</td></tr>
<tr><td colspan="3">Students who demonstrate understanding can:
3-5-EST-1-2. 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.</td></tr>
<tr><td colspan="3">The performance expectations above were developed using the following elements from the NRC document A Framework for K-12 Science Education:</td></tr>
<tr><td>Science and Engineering Practices
Constructing Explanations and Designing Solutions
Constructing explanations and designing solutions in 3–5 builds on K–2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems.
▪ Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design problem. (3-5-ETS1-2)</td><td>Disciplinary Core Ideas
ETS1.B: Developing Possible Solutions
▪ 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)</td><td>Crosscutting Concepts
Influence of Science, Engineering, and Technology on Society and the Natural World
▪ Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands. (3-5-ETS1-2)</td></tr>
<tr><td colspan="3">Articulation of DCIs across grade-bands: K-2.ETS1.A (3-5-ETS1-2); K-2.ETS1.B (3-5-ETS1-2); K-2.ETS1.C (3-5-ETS1-2); MS.ETS1.B (3-5-ETS1-2); MS.ETS1.C (3-5-ETS1-2)</td></tr>
<tr><td colspan="3">Common Core State Standards Connections:
ELA/Literacy –
RI.5.1 Quote accurately from a text when explaining what the text says explicitly and when drawing inferences from the text. (3-5-ETS1-2)
RI.5.7 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.5.9 Integrate information from several texts on the same topic in order to write or speak about the subject knowledgeably. (3-5-ETS1-2)
Mathematics –
MP.2 Reason abstractly and quantitatively. (3-5-ETS1-2)
MP.4 Model with mathematics. (3-5-ETS1-2)
MP.5 Use appropriate tools strategically. (3-5-ETS1-2)
3-5.OA Operations and Algebraic Thinking (3-5-ETS1-2)</td></tr>
</table>

3-5. Engineering Design

Students who demonstrate understanding can:

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.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations Planning and carrying out investigations to answer questions or test solutions to problems in 3–5 builds on K–2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions. ▪ 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)	**ETS1.B: Developing Possible Solutions** ▪ Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. (3-5-ETS1-3) **ETS1.C: Optimizing the Design Solution** ▪ Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (3-5-ETS1-3)	N/A

Articulation of DCIs across grade-bands: **K-2.ETS1.A** (3-5-ETS1-3); **K-2.ETS1.C** (3-5-ETS1-3); **MS.ETS1.B** (3-5-ETS1-3); **MS.ETS1.C** (3-5-ETS1-3)

Common Core State Standards Connections:

ELA/Literacy –

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

W.5.8 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.5.9 Draw evidence from literary or informational texts to support analysis, reflection, and research. *(3-5-ETS1-3)*

Mathematics –

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

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

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

Clarifying the standards

Prior learning

The following disciplinary core ideas are prior learning for the concepts in this unit of study. By the end of Grade 2, students know that:

- Maps show where things are located. One can map the shapes and kinds of land and water in any area.
- Water is found in oceans, rivers, lakes, and ponds. Water exists as solid ice and in liquid form.

By the end of the K-2 grade span, students know that:

- A situation that people want to change or create can be approached as a problem to be solved through engineering.
- Asking questions, making observations, and gathering information are helpful in thinking about problems.
- Before beginning to design a solution, it is important to clearly understand the problem.
- Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people.
- Because there is always more than one possible solution to a problem, it is useful to compare and test designs.

Progression of current learning

Driving question 1 How can maps be used to describe patterns of Earth's features?	
Concepts	Practices
• Patterns can be used as evidence to support an explanation. • Maps can help locate the different land and water features of Earth. • 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.	• Support an explanation using patterns as evidence. • Analyze and interpret data to make sense of phenomena using logical reasoning. • Analyze and interpret data from maps to describe patterns of Earth's features. Maps can include: – Topographic maps of Earth's land – Topographic maps of Earth's ocean floor – Locations of mountains – Locations of continental boundaries – Locations of volcanoes and earthquakes

Driving question 2 In what ways can the impacts of natural Earth processes on humans be reduced?	
Concepts	Practices
• Cause-and-effect relationships are routinely identified, tested, and used to explain change. • Engineers improve existing technologies or develop new ones to increase benefits, decrease known risks, and meet societal demands. • A variety of hazards result from natural processes (e.g., earthquakes, floods, tsunamis, volcanic eruptions). • Humans cannot eliminate the hazards, but they can take steps to reduce their impacts. • 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. • At whatever stage, communicating with peers about proposed solutions to a problem is an important part of the design process, and shared ideas can lead to improved designs. • Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. • Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints.	• 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 (Assessment is 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.

Integration of content, practices, and crosscutting concepts

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, that 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.

Integration of engineering

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.

Integration of DCI from other units within this grade level

In Grade 4, students will engage in engineering design in two additional units of study: Unit 7, Using Engineering Design with Force and Motion Systems, and Unit 8, Waves and Information. During these grade levels, students will learn that:

- 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.
- Research on a problem should be carried out before design of a solution begins. Testing a solution involves investigating how well it performs under a range of likely conditions.
- Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved.

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

Integration of English language arts and mathematics

English language arts

To support integration of the CCSS for English Language Arts in this unit, students should have access to multiple sources of information about Earth's features and earth processes. Students should have opportunities to read, analyze, and interpret information from nonfiction text, charts, graphs, diagrams, timelines, and interactive elements on the Internet. Students use this information, along with data they collect during investigations, to help explain, both orally and in writing, the patterns they observe in the features of the Earth and in the natural hazards that occur on the Earth.

As students engage in the engineering design process, they need opportunities to conduct research to build their understanding of how earth processes affect humans and to find examples of ways in which engineers reduce the effect of volcanic eruptions, earthquakes, floods, and tsunamis. Students should take notes as they read and summarize or paraphrase their notes to support their work throughout the engineering design process. In addition, students should provide a list of sources when using this type of information.

Mathematics

In this unit of study, students have multiple opportunities to integrate the CCSS for Mathematics. Students can:

- Use measurements to determine how far earthquakes and volcanoes tend to occur from continental boundaries.
- Analyze data to determine patterns of change that occur in areas where volcanoes erupt, earthquakes occur, and in flood zones.
- Reason abstractly and quantitatively to draw diagrams to build scale models.
- Analyze timelines, charts, and graphs to determine patterns in Earth's features and patterns of change caused by earth processes.
- Reason abstractly and quantitatively when discussing the effects of an earth process on humans. For example, on average, 3,000 lives are lost every year due to tsunamis. When early warning systems are in place, fewer than 1,000 lives are lost annually.
- Analyze constraints on materials, time, or cost to in order to determine criteria for design solutions.

Future learning

The following disciplinary core ideas are future learning related to concepts in this unit of study. In Grade 5, students will know that:

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

In middle school, students will know that:

- The geologic timescale interpreted from rock strata provides a way to organize Earth's history. Analysis of rock strata in the fossil record provides only relative dates, not an absolute scale.

- Tectonic processes continually generate new ocean sea floor at ridges and destroy old sea floor at trenches.
- All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and the matter that cycles produce chemical and physical changes in Earth's materials and living organisms.
- The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future.
- Maps of ancient land and water patterns, based on investigations of rock and fossils, make clear how Earth's plates have moved great distances, collided, and spread apart.
- Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces, can help forecast the locations and likelihoods of future events.
- A solution needs to be tested, and then modified on the basis of the test results, in order to improve it.
- There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem.
- Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors.
- Models of all kinds are important fro testing solutions.
- Although one design may not perform the best across all tests, identifying the characteristics of the design that perform the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design.
- The iterative process of testing the most promising solutions and modifying them on the basis of the tests results leads to greater refinement and ultimately to an optimal solution.

Number of Instructional Days

Recommended number of instructional days: 12 (1 day = approximately 45–60 minutes)

Note—The recommended number of days is an estimate based on the information available at this time. Teachers are strongly encouraged to review the entire unit of study carefully and collaboratively to determine whether adjustments to this estimate need to be made.