# 5th Grade – Thematic Model - Bundle 3
# Stability and Change in Earth's Systems

*This is the third bundle of the Fifth Grade Thematic Model. Each bundle has connections to the other bundles in the course, as shown in the Course Flowchart.*

*Bundle 3 Question: This bundle is assembled to address the question* "Has the desert always been dry?"

**Summary**

The bundle organizes performance expectations with a focus on helping students build understanding of how Earth systems change or stay the same over time. Instruction developed from this bundle should always maintain the three-dimensional nature of the standards, and is not limited to the practices and concepts directly linked with any of the bundle performance expectations.

**Connections between bundle DCIs**

The idea that matter of any type can be subdivided into particles that are too small to see (PS1.A as in 5-PS1-1) can connect to the concept that Earth's major systems interact in multiple ways to affect Earth's surface materials and processes (ESS2.A as in 5-ESS2-1) since matter sometimes moves through the systems as particles that are too small to see. Earth's major systems also connect to the concept that nearly all of Earth's available water is in the ocean, and most fresh water is in glaciers or underground; only a tiny fraction is in streams, lakes, wetlands, and the atmosphere (ESS2.C as in 5-ESS2-2) as this concept is about the hydrosphere.

The Earth's major systems are affected by gravity as the gravitational force of Earth acting on an object near Earth's surface pulls that object toward the planet's center (PS2.B as in 5-PS2-1). The concept of gravitational force can also connect to the concept that the Earth orbits around the sun and the moon around Earth (ESS1.B as in 5-ESS1-2).

The engineering design concept that communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs (ETS1.B as in 3-5-ETS1-2) could connect to multiple science concepts, such as that the ocean supports a variety of ecosystems and organisms (ESS2.A as in 5-ESS2-1) and that nearly all of Earth's available water is in the ocean, and most fresh water is in glaciers or underground; only a tiny fraction is in streams, lakes, wetlands, and the atmosphere (ESS2.C as in 5-ESS2-2). The first connection could be made by having students share ideas about designs regarding threatened ecosystems or organisms that are supported by the ocean. The second could be made by having students independently obtain information about processes to obtain drinkable water, and then share their findings with others to propose improved designs. In either case, students should have an opportunity to communicate with their peers throughout the design process and reflect on how sharing ideas affected their designs.

**Bundle Science and Engineering Practices**

Instruction leading to this bundle of PEs will help students build toward proficiency in elements of the practices of developing and using models (5-PS1-1 and 5-ESS2-1); analyzing and interpreting data (5-ESS1-2); using mathematical and computational thinking (5-ESS2-2); constructing explanations and designing solutions **(**3-5-ETS1-2); engaging in argument from evidence (5-PS2-1); and obtaining, evaluating, and communicating Information (5-ESS3-1). Many other practice elements can be used in instruction.

**Bundle Crosscutting Concepts**

Instruction leading to this bundle of PEs will help students build toward proficiency in elements of the crosscutting concepts of Patterns (5-ESS1-2); Cause and Effect (5-PS2-1); Scale, Proportion, and Quantity (5-PS1-1 and 5-ESS2-2); and Systems and System Models (5-ESS2-1). Many other crosscutting concepts elements can be used in instruction.

*All instruction should be three-dimensional.*

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| **Performance Expectations**<br><br>5-PS1-1 and 5-ESS2-1 are partially assessable | 5-PS1-1. **Develop a model to describe that matter is made of particles too small to be seen.** [Clarification Statement: Examples of evidence supporting a model could include adding air to expand a basketball, compressing air in a syringe, dissolving sugar in water, and evaporating salt water.] [*Assessment Boundary: Assessment does not include the atomic-scale mechanism of evaporation and condensation or defining the unseen particles.*]<br><br>5-PS2-1. **Support an argument that the gravitational force exerted by Earth on objects is directed down.** [Clarification Statement: "Down" is a local description of the direction that points toward the center of the spherical Earth.] [*Assessment Boundary: Assessment does not include mathematical representation of gravitational force.*]<br><br>5-ESS1-2. **Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.** [Clarification Statement: Examples of patterns could include the position and motion of Earth with respect to the sun and selected stars that are visible only in particular months.] [*Assessment Boundary: Assessment does not include causes of seasons.*]<br><br>5-ESS2-1. **Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.** [Clarification Statement: Examples could include the influence of the ocean on ecosystems, landform shape, and climate; the influence of the atmosphere on landforms and ecosystems through weather and climate; and the influence of mountain ranges on winds and clouds in the atmosphere. The geosphere, hydrosphere, atmosphere, and biosphere are each a system.] [*Assessment Boundary: Assessment is limited to the interactions of two systems at a time.*]<br><br>5-ESS2-2. **Describe and graph the amounts of salt water and fresh water in various reservoirs to provide evidence about the distribution of water on Earth.** [*Assessment Boundary: Assessment is limited to oceans, lakes, rivers, glaciers, ground water, and polar ice caps, and does not include the atmosphere.*]<br><br>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.** |
| **Example Phenomena** | The Amazon rainforest receives a lot of rain.<br><br>There are usually clouds around a mountaintop. |
| **Additional Practices Building to the PEs** | **Asking Questions and Defining Problems**<br>● Identify scientific (testable) and non-scientific (non-testable) questions.<br>Students could *identify scientific (testable) and non-scientific (non-testable) questions* [about] ***interactions*** [between] ***Earth's major systems – the geosphere (solid and molten rock, soil, and sediments), the hydrosphere (water and ice), the atmosphere (air), and the biosphere (living things, including humans)***. 5-ESS2-1<br><br>**Developing and Using Models**<br>● Develop a diagram or simple physical prototype to convey a proposed object, tool, or process.<br>Students could *develop a diagram to convey a proposed process* [for creating] ***fresh water***. 5-ESS2-2<br><br>**Planning and Carrying Out Investigations**<br>● Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution.<br>Students could *make observations to serve as the basis for evidence for an explanation* [that] ***the gravitational force of Earth acting on an object near Earth's surface pulls that object toward the planet's center***. 5-PS2-1 |

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| **Additional Practices Building to the PEs (Continued)** | **Analyzing and Interpreting Data**<br>● Analyze and interpret data to make sense of phenomena using logical reasoning, mathematics, and/or computation.<br>Students could *analyze and interpret data to make sense of* [the distribution and accessibility of water on Earth, i.e., that] ***nearly all of Earth's available water is in the ocean***. 5-ESS2-2<br><br>**Using Mathematical and Computational Thinking**<br>● Decide if qualitative or quantitative data are best to determine whether a proposed object or tool meets criteria for success.<br>Students could *decide if qualitative or quantitative data are best* [for] **detecting the existence of matter** [when] **matter is subdivided into particles that are too small to see**. 5-PS1-1<br><br>**Constructing Explanations and Designing Solutions**<br>● Identify the evidence that supports particular points in an explanation.<br>Students could *identify the evidence that supports particular points in an explanation* [that] ***any type of matter can be subdivided into particles that are too small to see***. 5-PS1-1<br><br>**Engaging in Argument from Evidence**<br>● Distinguish among facts, reasoned judgment based on research findings, and speculation in an explanation.<br>Students could *distinguish among facts, reasoned judgment, and speculation in an explanation* [related to] ***Earth's major systems interacting in multiple ways to affect Earth's surface materials***. 5-ESS2-1<br><br>**Obtaining, Evaluating and Communicating Information**<br>● Communicate scientific and/or technical information orally and/or in written formats, including various forms of media as well as tables, diagrams, and charts.<br>Students could *communicate* [that] ***the gravitational force of Earth acting on an object near Earth's surface pulls that object toward the planet's center,*** [using] *written formats as well as tables, diagrams, and charts*. 5-PS2-1 |
| **Additional Crosscutting Concepts Building to the PEs** | **Cause and Effect**<br>● Cause and effect relationships are routinely identified, tested, and used to explain change.<br>Students could *identify cause and effect relationships* [between] ***Earth's major systems*** [and] ***Earth's surface materials and processes*** *and use* [the relationships] *to explain change*. 5-ESS2-1<br><br>**Systems and System Models**<br>● A system can be described in terms of its components and their interactions.<br>Students could describe ***the gravitational force of Earth acting on an object*** *as a system,* [and identify] *its components and their interactions*. 5-PS2-1 |

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| **Additional Crosscutting Concepts Building to the PEs (Continued)** | **Stability and Change**<br>● Change is measured in terms of differences over time and may occur at different rates.<br>Students could describe that *change is measured in terms of differences over time and may occur at different rates,* [using examples from the interactions of] ***Earth's major systems,*** [such as] ***winds and clouds in the atmosphere interacting with the landforms to determine patterns of weather***. 5-ESS2-1 |
| **Additional Connections to Nature of Science** | **Scientific Knowledge Assumes an Order and Consistency in Natural Systems**<br>● Basic laws of nature are the same everywhere in the universe.<br>Students could describe whether the *basic laws of nature* – [such as] **the gravitational force** – *are the same everywhere in the universe*. 5-PS2-1<br><br>**Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena**<br>● Science explanations describe the mechanisms for natural events.<br>Students could describe how *science explanations describe the mechanisms for natural events*, [such as] ***winds and clouds in the atmosphere interacting with the landforms to determine patterns of weather***. 5-ESS2-1 |

## 5-PS1-1 Matter and Its Interactions

Students who demonstrate understanding can:

**5-PS1-1.** **Develop a model to describe that matter is made of particles too small to be seen.** [Clarification Statement: Examples of evidence supporting a model could include adding air to expand a basketball, compressing air in a syringe, dissolving sugar in water, and evaporating salt water.] [*Assessment Boundary: Assessment does not include the atomic-scale mechanism of evaporation and condensation or defining the unseen particles.*]

The performance expectation above was 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 |
|---|---|---|
| **Developing and Using Models**<br>Modeling in 3–5 builds on K–2 experiences and progresses to building and revising simple models and using models to represent events and design solutions.<br>• Use models to describe phenomena. | **PS1.A: Structure and Properties of Matter**<br>• Matter of any type can be subdivided into particles that are too small to see, but even then the matter still exists and can be detected by other means. A model showing that gases are made from matter particles that are too small to see and are moving freely around in space can explain many observations, including the inflation and shape of a balloon and the effects of air on larger particles or objects. | **Scale, Proportion, and Quantity**<br>• Natural objects exist from the very small to the immensely large. |

| Observable features of the student performance by the end of the grade: | | | |
|---|---|---|---|
| 1 | Components of the model | | |
| | a | Students develop a model to describe* a phenomenon that includes the idea that matter is made of particles too small to be seen. In the model, students identify the relevant components for the phenomenon, including: | |
| | | i. | Bulk matter (macroscopic observable matter; e.g., as sugar, air, water). |
| | | ii. | Particles of matter that are too small to be seen. |
| 2 | Relationships | | |
| | a | In the model, students identify and describe* relevant relationships between components, including the relationships between: | |
| | | i. | Bulk matter and tiny particles that cannot be seen (e.g., tiny particles of matter that cannot be seen make up bulk matter). |
| | | ii. | The behavior of a collection of many tiny particles of matter and observable phenomena involving bulk matter (e.g., an expanding balloon, evaporating liquids, substances that dissolve in a solvent, effects of wind). |
| 3 | Connections | | |
| | a | Students use the model to describe* how matter composed of tiny particles too small to be seen can account for observable phenomena (e.g., air inflating a basketball, ice melting into water). | |

## 5-PS2-1 Motion and Stability: Forces and Interaction

Students who demonstrate understanding can:

**5-PS2-1.** **Support an argument that the gravitational force exerted by Earth on objects is directed down.** [Clarification Statement: "Down" is a local description of the direction that points toward the center of the spherical Earth.] [*Assessment Boundary: Assessment does not include mathematical representation of gravitational force.*]

The performance expectation above was 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 |
|---|---|---|
| **Engaging in Argument from Evidence**<br>Engaging in argument from evidence in 3–5 builds on K–2 experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world(s).<br>• Support an argument with evidence, data, or a model. | **PS2.B: Types of Interactions**<br>• The gravitational force of Earth acting on an object near Earth's surface pulls that object toward the planet's center. | **Cause and Effect**<br>• Cause and effect relationships are routinely identified and used to explain change. |

| Observable features of the student performance by the end of the grade: | | | |
|---|---|---|---|
| 1 | Supported claims | | |
| | a | Students identify a given claim to be supported about a phenomenon. The claim includes the idea that the gravitational force exerted by Earth on objects is directed down toward the center of Earth. | |
| 2 | Identifying scientific evidence | | |
| | a | Students identify and describe* the given evidence, data, and/or models that support the claim, including: | |
| | | i. | Multiple lines of evidence that indicate that the Earth's shape is spherical (e.g., observation of ships sailing beyond the horizon, the shape of the Earth's shadow on the moon during an eclipse, the changing height of the North Star above the horizon as people travel north and south). |
| | | ii. | That objects dropped appear to fall straight down. |
| | | iii. | That people live all around the spherical Earth, and they all observe that objects appear to fall straight down. |
| 3 | Evaluation and critique | | |
| | a | Students evaluate the evidence to determine whether it is sufficient and relevant to supporting the claim. | |
| | b | Students describe* whether any additional evidence is needed to support the claim. | |
| 4 | Reasoning and synthesis | | |
| | a | Students use reasoning to connect the relevant and appropriate evidence to support the claim with argumentation. Students describe* a chain of reasoning that includes: | |
| | | i. | If Earth is spherical, and all observers see objects near them falling directly "down" to the Earth's surface, then all observers would agree that objects fall toward the Earth's center. |
| | | ii. | Since an object that is initially stationary when held moves downward when it is released, there must be a force (gravity) acting on the object that pulls the object toward the center of Earth. |

## 5-ESS1-2 Earth's Place in the Universe

Students who demonstrate understanding can:

**5-ESS1-2.** **Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.** [Clarification Statement: Examples of patterns could include the position and motion of Earth with respect to the sun and selected stars that are visible only in particular months.] [*Assessment Boundary: Assessment does not include causes of seasons.*]

The performance expectation above was 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**<br>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.<br>• Represent data in graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships. | **ESS1.B: Earth and the Solar System**<br>• The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns. These include day and night; daily changes in the length and direction of shadows; and different positions of the sun, moon, and stars at different times of the day, month, and year. | **Patterns**<br>• Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena. |

| Observable features of the student performance by the end of the grade: | | | |
|---|---|---|---|
| 1 | Organizing data | | |
| | a | Using graphical displays (e.g., bar graphs, pictographs), students organize data pertaining to daily and seasonal changes caused by the Earth's rotation and orbit around the sun. Students organize data that include: | |
| | | i. | The length and direction of shadows observed several times during one day. |
| | | ii. | The duration of daylight throughout the year, as determined by sunrise and sunset times. |
| | | iii. | Presence or absence of selected stars and/or groups of stars that are visible in the night sky at different times of the year. |
| 2 | Identifying relationships | | |
| | a | Students use the organized data to find and describe* relationships within the datasets, including: | |
| | | i. | The apparent motion of the sun from east to west results in patterns of changes in length and direction of shadows throughout a day as Earth rotates on its axis. |
| | | ii. | The length of the day gradually changes throughout the year as Earth orbits the sun, with longer days in the summer and shorter days in the winter. |
| | | iii. | Some stars and/or groups of stars (i.e., constellations) can be seen in the sky all year, while others appear only at certain times of the year. |
| | b | Students use the organized data to find and describe* relationships among the datasets, including: | |
| | | i. | Similarities and differences in the timing of observable changes in shadows, daylight, and the appearance of stars show that events occur at different rates (e.g., Earth rotates on its axis once a day, while its orbit around the sun takes a full year). |

## 5-ESS2-1 Earth's Systems

Students who demonstrate understanding can:

**5-ESS2-1.** **Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.** [Clarification Statement: Examples could include the influence of the ocean on ecosystems, landform shape, and climate; the influence of the atmosphere on landforms and ecosystems through weather and climate; and the influence of mountain ranges on winds and clouds in the atmosphere. The geosphere, hydrosphere, atmosphere, and biosphere are each a system.] [*Assessment Boundary: Assessment is limited to the interactions of two systems at a time.*]

The performance expectation above was 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 |
|---|---|---|
| **Developing and Using Models**<br>Modeling in 3–5 builds on K–2 experiences and progresses to building and revising simple models and using models to represent events and design solutions.<br>• Develop a model using an example to describe a scientific principle. | **ESS2.A: Earth Materials and Systems**<br>• Earth's major systems are the geosphere (solid and molten rock, soil, and sediments), the hydrosphere (water and ice), the atmosphere (air), and the biosphere (living things, including humans). These systems interact in multiple ways to affect Earth's surface materials and processes. The ocean supports a variety of ecosystems and organisms, shapes landforms, and influences climate. Winds and clouds in the atmosphere interact with the landforms to determine patterns of weather. | **Systems and System Models**<br>• A system can be described in terms of its components and their interactions. |

| Observable features of the student performance by the end of the grade: | | | |
|---|---|---|---|
| 1 | Components of the model | | |
| | a | Students develop a model, using a specific given example of a phenomenon, to describe* ways that the geosphere, biosphere, hydrosphere, and/or atmosphere interact. In their model, students identify the relevant components of their example, including features of two of the following systems that are relevant for the given example: | |
| | | i. | Geosphere (i.e., solid and molten rock, soil, sediment, continents, mountains). |
| | | ii. | Hydrosphere (i.e., water and ice in the form of rivers, lakes, glaciers). |
| | | iii. | Atmosphere (i.e., wind, oxygen). |
| | | iv. | Biosphere (i.e., plants, animals [including humans]). |
| 2 | Relationships | | |
| | a | Students identify and describe* relationships (interactions) within and between the parts of the Earth systems identified in the model that are relevant to the example (e.g., the atmosphere and the hydrosphere interact by exchanging water through evaporation and precipitation; the hydrosphere and atmosphere interact through air temperature changes, which lead to the formation or melting of ice). | |
| 3 | Connections | | |
| | a | Students use the model to describe* a variety of ways in which the parts of two major Earth systems in the specific given example interact to affect the Earth's surface materials and processes in that context. Students use the model to describe* how parts of an individual Earth system: | |
| | | i. | Work together to affect the functioning of that Earth system. |
| | | ii. | Contribute to the functioning of the other relevant Earth system. |

## 5-ESS2-2 Earth's Systems

Students who demonstrate understanding can:

**5-ESS2-2.** **Describe and graph the amounts of salt water and fresh water in various reservoirs to provide evidence about the distribution of water on Earth.** [*Assessment Boundary: Assessment is limited to oceans, lakes, rivers, glaciers, ground water, and polar ice caps, and does not include the atmosphere.*]

The performance expectation above was 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 |
|---|---|---|
| **Using Mathematics and Computational Thinking**<br>Mathematical and computational thinking in 3–5 builds on K–2 experiences and progresses to extending quantitative measurements to a variety of physical properties and using computation and mathematics to analyze data and compare alternative design solutions.<br>• Describe and graph quantities such as area and volume to address scientific questions. | **ESS2.C: The Roles of Water in Earth's Surface Processes**<br>• Nearly all of 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. | **Scale, Proportion, and Quantity**<br>• Standard units are used to measure and describe physical quantities such as weight and volume. |

| Observable features of the student performance by the end of the grade: | | | |
|---|---|---|---|
| 1 | Representation | | |
| | a | Students graph the given data (using standard units) about the amount of salt water and the amount of fresh water in each of the following reservoirs, as well as in all the reservoirs combined, to address a scientific question: | |
| | | i. | Oceans. |
| | | ii. | Lakes. |
| | | iii. | Rivers. |
| | | iv. | Glaciers. |
| | | v. | Ground water. |
| | | vi. | Polar ice caps. |
| 2 | Mathematical/computational analysis | | |
| | a | Students use the graphs of the relative amounts of total salt water and total fresh water in each of the reservoirs to describe* that: | |
| | | i. | The majority of water on Earth is found in the oceans. |
| | | ii. | Most of the Earth's fresh water is stored in glaciers or underground. |
| | | iii. | A small fraction of fresh water is found in lakes, rivers, wetlands, and the atmosphere. |

## 3-5-ETS1-2 Engineering Design

Students who demonstrate understanding can:

**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.**

The performance expectation above was 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**<br>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.<br>• Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design problem. | **ETS1.B: Developing Possible Solutions**<br>• 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.<br>• 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. | **Influence of Science, Engineering, and Technology on Society and the Natural World**<br>• Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands. |

| Observable features of the student performance by the end of the grade: | | | |
|---|---|---|---|
| 1 | Using scientific knowledge to generate design solutions | | |
| | a | Students use grade-appropriate information from research about a given problem, including the causes and effects of the problem and relevant scientific information. | |
| | b | Students generate at least two possible solutions to the problem based on scientific information and understanding of the problem. | |
| | c | Students specify how each design solution solves the problem. | |
| | d | Students share ideas and findings with others about design solutions to generate a variety of possible solutions. | |
| | e | Students describe* the necessary steps for designing a solution to a problem, including conducting research and communicating with others throughout the design process to improve the design [note: emphasis is on what is necessary for designing solutions, not on a step-wise process]. | |
| 2 | Describing* criteria and constraints, including quantification when appropriate | | |
| | a | Students describe*: | |
| | | i. | The given criteria (required features) and constraints (limits) for the solutions, including increasing benefits, decreasing risks/costs, and meeting societal demands as appropriate. |
| | | ii. | How the criteria and constraints will be used to generate and test the design solutions. |
| 3 | Evaluating potential solutions | | |
| | a | Students test each solution under a range of likely conditions and gather data to determine how well the solutions meet the criteria and constraints of the problem. | |
| | b | Students use the collected data to compare solutions based on how well each solution meets the criteria and constraints of the problem. | |