While Unit 1 focused heavily on life science, this unit engages students in the intersection of Earth Science, Physical Science, and Engineering. In this unit, students consider what factors create regions with extreme climates and how people can use thermal technology to survive in those regions. In this culminating project, students are asked to select a region with an extreme hot or cold climate and design a device that can make living in that climate more tolerable.

The integrated model requires students to access and use a wide range of ideas from prior grades. This content knowledge spans seven different Disciplinary Core Ideas in this unit: ESS2.C: The Roles of Water in Earth’s Surface Processes, ESS2.D: Weather and Climate, PS3.A: Definitions of Energy, PS3.B: Conservation of Energy and Energy Transfer, ETS1.A: Defining and Delimiting Engineering Problems, ETS1.B: Developing Possible Solutions, and ETS1.C: Optimizing the Design Solution.

As students explore these core ideas, they build on their skills in the following science and engineering practices: Asking Questions and Defining Problems, Developing and Using Models, Planning and Carrying Out Investigations, Analyzing and Interpreting Data, and Designing Solutions. In addition to science and engineering practices, students also continue to build on their knowledge of the following crosscutting concepts: Patterns; Scale, Proportion, and Quantity; Systems and System Models; and Energy and Matter.

\*This summary is based on information found in the NGSS Framework.

**K-8 Progression of Disciplinary Core Ideas, Science and Engineering Practices, and Crosscutting Concepts for Unit 2**

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| **Disciplinary Core Ideas** | **K-2** | **3-5** | **6-8** |
| **ESS2.C**  **The Roles of Water in Earth’s Surface Processes** | Water is found in may types of places and in different forms on Earth. | Most of Earth’s water is in the ocean and much of the Earth’s freshwater is in glaciers or underground. | Water cycles among land, ocean, and atmosphere, and is propelled by sunlight and gravity. Density variations of seawater drive interconnected ocean currents. |
| **ESS2.D**  **Weather and Climate** | Weather is the combination of sunlight, snow or rain, and temperature in a particular region and time. People record weather patterns over time. | Climate describes patterns of typical weather conditions over different scales and variations. Historical weather patterns can be analyzed. | Complex interactions determine local weather patterns and influence climate, including the role of the ocean. |
| **PS3.A**  **Definitions of Energy** | N/A | Moving objects contain energy. The faster the object moves, the more energy it has. Energy can be converted from one form to another form. | Energy changes to and from each type can be tracked through physical or chemical interactions. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter. |
| **PS3.B**  **Conservation of Energy and Energy Transfer** | Content found in PS3.D (Sunlight warms the Earth’s surface). |
| **ETS1.A**  **Defining and Delimiting Engineering Problems** | A situation that people want to change or create can be approached as a problem to be solved through engineering. Such problems may have many acceptable solutions. 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. | 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. | The more precisely a design task’s criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions. |
| **ETS1.B**  **Developing Possible Solutions** | 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. | 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 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. | 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 for testing solutions. |
| **ETS1.C**  **Optimizing the Design Solution** | Because there is always more than one possible solution to a problem, it is useful to compare and test designs. | Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. | Although one design may not perform the best across all tests, identifying the characteristics of the design that performed 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 what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. |

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| **Science and Engineering Practices** | **K-2** | **3-5** | **6-8** |
| **Asking Questions and Defining Problems\*** | Asking questions and defining problems in K-2 builds on prior experiences and progresses to simple descriptive questions that can be tested.   * Define a simple problem that can be solved through the development of a new or improved object or tool. | Asking questions and defining problems in 3-5 builds on prior experiences and progresses to specifying qualitative relationships.   * Use prior knowledge to describe problems that can be solved. * 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. | Asking questions and defining problems in 6-8 builds on prior experiences and progresses to specifying relationships between variables, and clarifying arguments and models.   * Define a design problem that can be solved through the development of an object, tool, process, or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions. |
| **Developing and Using Models\*** | Modeling in K-2 builds on prior experiences and progresses to include using and developing models (i.e., diagram, drawing, physical replica, diorama, dramatization, or storyboard) that represent concrete events or design solutions.   * Develop and/or use a model to represent amounts, relationships, relative scales (bigger/smaller), and/or patterns in the natural and designed world(s). | Modeling in 3-5 builds on prior experiences and progresses to building and revising simple models and using models to represent events and design solutions.   * Develop and/or use models to describe and/or predict phenomena. * Develop a model using an analogy, example, or abstract representation to describe a scientific principle or design solution. | Modeling in 6-8 builds on prior experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.   * Develop and use a model to describe phenomena. * Develop and use a model to describe unobservable mechanisms. |
| **Planning and Carrying Out Investigations\*** | Planning and carrying out investigations in K-2 builds on prior experiences and progresses to simple investigations, based on fair tests, which provide data to support explanations or design solutions.   * Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence to answer a question. | Planning and carrying out investigations in 3-5 builds on prior 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. | Planning and carrying out investigations in 6-8 builds on prior experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or design solutions.   * Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim. |
| **Analyzing and Interpreting Data\*** | Analyzing data in K-2 builds on prior experiences and progresses to collecting, recording, and sharing observations.   * Compare predictions (based on prior experiences) to what occurred (observable events). | Analyzing data in 3-5 builds on prior 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.   * Compare and contrast data collected by different groups in order to discuss similarities and differences in their findings. | Analyzing data in 6-8 builds on prior experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.   * Analyze and interpret data to determine similarities and differences in findings.\* |
| **Designing Solutions\*** | Designing solutions in K-2 builds on prior experiences and progresses to the use of evidence and ideas in designing solutions.   * Generate and/or compare multiple solutions to a problem. | Designing solutions in 3-5 builds on prior experiences and progresses to the use of evidence in designing multiple solutions to design problems.   * Apply scientific ideas to solve design problems. | Designing solutions in 6-8 builds on prior experiences and progresses to include designing solutions supported by multiple sources of evidence consistent with scientific knowledge, principles, and theories.   * Apply scientific ideas or principles to design an object, tool, process or system. |

\*These SEPs are summatively assessed using the Culminating Project or a Task-Specific Rubric.

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| **Crosscutting Concepts** | **K-2** | **3-5** | **6-8** |
| **Patterns\*** | Students recognize that patterns in the natural and human designed world can be observed, used to describe phenomena, and used as evidence.   * Patterns in the natural and human designed world can be observed, used to describe phenomena, and used as evidence. | Students identify similarities and differences in order to sort and classify natural objects and designed products. They identify patterns related to time, including simple rates of change and cycles, and to use these patterns to make predictions.   * Patterns of change can be used to make predictions. * Patterns can be used as evidence to support an explanation. | Students recognize that macroscopic patterns are related to the nature of microscopic and atomic-level structure. They identify patterns in rates of change and other numerical relationships that provide information about natural and human designed systems. They use patterns to identify cause and effect relationships, and use graphs and charts to identify patterns in data.   * Patterns can be used to identify cause-and-effect relationships. |
| **Scale, Proportion, and Quantity\*** | Students use relative scales (e.g., bigger and smaller; hotter and colder; faster and slower) to describe objects. They use standard units to measure length.   * Relative scales allow objects and events to be compared and described (e.g., bigger and smaller; hotter and colder; faster and slower). | Students recognize natural objects and observable phenomena exist from the very small to the immensely large. They use standard units to measure and describe physical quantities such as weight, time, temperature, and volume.   * Natural objects and/or observable phenomena exist from the very small to the immensely large or from very short to very long time periods. | Students observe time, space, and energy phenomena at various scales using models to study systems that are too large or too small. They understand phenomena observed at one scale may not be observable at another scale, and the function of natural and designed systems may change with scale. They use proportional relationships (e.g., speed as the ratio of distance traveled to time taken) to gather information about the magnitude of properties and processes. They represent scientific relationships through the use of algebraic expressions and equations.   * Proportional relationships (e.g., speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes. |
| **Systems and System Models\*** | Students understand objects and organisms can be described in terms of their parts; and systems in the natural and designed world have parts that work together.   * Systems in the natural and designed world have parts that work together. | Students understand that a system is a group of related parts that make up a whole and can carry out functions its individual parts cannot. They can also describe a system in terms of its components and their interactions.   * A system can be described in terms of its components and their interactions. | Students can understand that systems may interact with other systems; they may have sub-systems and be a part of larger complex systems. They can use models to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems. They can also learn that models are limited in that they only represent certain aspects of the system under study.   * Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy and matter flows within systems. |
| **Energy and Matter\*** | Students observe objects may break into smaller pieces, be put together into larger pieces, or change shapes.   * Objects may break into smaller pieces, be put together into larger pieces, or change shapes. | Students learn matter is made of particles and energy can be transferred in various ways and between objects. Students observe the conservation of matter by tracking matter flows and cycles before and after processes and recognizing the total weight of substances does not change.   * Matter is transported into, out of, and within systems. * Energy can be transferred in various ways and between objects. | Students learn matter is conserved because atoms are conserved in physical and chemical processes. They also learn that within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter.   * Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter. |

\*These CCCs are summatively assessed using the Culminating Project or a Task-Specific Rubric.

**Progression of Knowledge from Kindergarten – 8th grade**

ESS2.C. The Role of Water in Earth’s Surface Processes: In Kindergarten through second grade, students begin to gather information about where water can be found on Earth, whether it be in solid or liquid form. In fifth grade, students analyze more specific data about the reservoirs that they identified in K-2 and make the distinction between freshwater and saltwater. By graphing the amount of water in oceans, lakes, rivers, glaciers, groundwater, and polar ice caps, they are able to realize that nearly all of Earth’s water is in the ocean and most freshwater is in glaciers or underground, not rivers and lakes. While these Performance Expectations lay the foundation by showing students where water is located on Earth, the middle school Performance Expectations take a great leap in this DCI. In this unit, students move towards examining how water cycles amongst Earth systems, what causes water to cycle, and how the movement of water results in weather patterns and ocean currents. In seventh and eighth grade, students continue to explore this DCI as they examine how water causes weathering and erosion that change land’s features. Because of the vast number of Performance Expectations, students engage in a wide variety of Science and Engineering Practices and Crosscutting Concepts.

The following is the progression of the Performance Expectations for this DCI:

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| **2-ESS2-3** | Obtain information to identify where water is found on Earth and that it can be solid or liquid. |
| **5-ESS2-2** | Describe and graph the amounts and percentages of water and fresh water in various reservoirs to provide evidence about the distribution of water on Earth. |
| **MS-ESS2-2** | Construct an explanation based on evidence for how geoscience processes have changed Earth’s surface at varying time and spatial scales. |
| **MS-ESS2-4** | Develop a model to describe the cycling of water through Earth’s systems driven by energy from the sun and the force of gravity. |
| **MS-ESS2-5** | Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions. |
| **MS-ESS2-6** | Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates. |

ESS2.D. Weather and Climate: Students do not engage with this DCI until the third grade. In third grade, students begin to distinguish between weather and climate by using data to describe weather patterns for one PE and gathering information to describe climate conditions for another PE. Because of the nature of this content, students are focusing on the CCC of Patterns at this level. This sets the stage for them to explore the actual mechanisms behind weather and climate at the middle school level. In this unit, students use models to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine climates. In the next unit, students will build on this knowledge to move away from climate and consider how interactions of air masses result in specific weather conditions. Because the middle school PEs deal more with the causes of weather and climate, students emphasize the CCCs of Systems and System Models and Cause and Effect at this grade band.

The following is the progression of the Performance Expectations for this DCI:

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| **3-ESS2-1** | Represent data in tables and graphical displays to describe typical weather conditions for a particular season. |
| **3-ESS2-2** | Obtain and combine information to describe climates in different regions of the world. |
| **MS-ESS2-5** | Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions. |
| **MS-ESS2-6** | Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates. |

PS3.A. Definitions of Energy: Students do not engage with this DCI until the fourth grade. In third through fifth grade, students begin to connect motion with energy, asking questions like: What is energy and how is it related to motion? How is energy transferred? Because energy is a difficult concept for students to conceptualize at this age, these performance expectations deal mostly with experiential knowledge. By the end of this grade band, students will understand that the faster a given object is moving, the more energy it possesses, and if it collides with another object, it can transfer some of that energy in motion. While these contexts are very different from those in this unit, this prior knowledge helps students begin to associate kinetic energy with motion and energy transfer with heat—two core concepts for this unit. In this unit, students investigate how temperature is a measure of the average kinetic energy particles of matter and this depends on the types, states, and amounts of matter present. They then use this knowledge to design a device that maximizes or minimizes thermal energy transfer. In later middle school units, students will return to other more tangible concepts of energy and motion through other PEs (not shown below). Because of the variety in contexts around energy, students engage in a wide variety of Science and Engineering Practices and Crosscutting Concepts for this DCI.

The following is the progression of the Performance Expectations for this DCI:

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| **4-PS3-1** | Use evidence to construct an explanation relating the speed of an object to the energy of that object. |
| **4-PS3-2** | Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents. |
| **4-PS3-3** | Ask questions and predict outcomes about the changes in energy that occur when objects collide. |
| **MS-PS3-3** | Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.\* |
| **MS-PS3-4** | Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample |

PS3.B. Conservation of Energy and Energy Transfer: In Kindergarten through second grade, students are first introduced to the idea of energy transfer by making observations of how sunlight warms the Earth’s surface and designing a device that can minimize this energy transfer. In third – fifth grade, students broaden their definition of energy from light and heat to include other indicators of energy (e.g., motion, sound, or electrical energy). As they investigate these types of energy, they also conceptualize how energy can be transferred between objects, resulting in different types of observable evidence. For example, when moving objects collide, energy is transferred to the surrounding air, producing heat and sound. This set the foundation for Unit 1, in which students used their knowledge of observable forms of energy to consider how energy transfers between objects are also associated with changes in kinetic energy. In this unit, students still explore energy transfer, but specifically focus on thermal energy transfer. While there is a clear focus on the CCC of Energy and Matter in this DCI, students also build their understanding of Cause and Effect and Scale, Proportion, and Quantity at different grade levels. Throughout all grade bands, there is a focus on the SEPs of Asking Questions, Planning and Carrying Out Investigations, and Designing Solutions.

The following is the progression of the Performance Expectations for this DCI:

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| **K-PS3-1** | Make observations to determine the effect of sunlight on Earth’s surface. |

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| **K-PS3-2**  **4-PS3-2** | Use tools and materials to design and build a structure that will reduce the warming effect of sunlight on an area.  Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electrical currents. |
| **4-PS3-3** | Ask questions and predict outcomes about the changes in energy that occur when objects collide. |
| **4-PS3-4** | Apply scientific ideas to design, test, and refine a device that converts energy from one form to another. |
| **MS-PS3-3** | Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer. |
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| **MS-PS3-4** | Plan an investigation to determine the relationships among the energy transferred and the change in the average kinetic energy of the particles as measured by the temperature of the sample. |
| **MS-PS3-5** | Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object. |

ETS1.A. Defining and Delimiting Engineering Problems: In Kindergarten through second grade, students first begin to approach situations as problems to be solved through engineering. They learn to ask questions and gather information to clearly understand a problem. In third through fifth grade, students build on understanding the problem to also identifying criteria and constraints surrounding the problem. In this sixth grade unit, students take this process a step further by defining criteria and constraints more precisely, including consideration of scientific principles and other relevant knowledge. In Kindergarten to second grade, students focus on the science and engineering practice of Asking Questions in order to help them with the practice of Defining Problems, which continues to be the main focus in subsequent grades.

The following is the progression of the Performance Expectations for this DCI:

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| **K-2-ETS1-1** | Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool. |
| **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. |
| **MS-ETS1-1** | Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. |

ETS1.B. Developing Possible Solutions: In Kindergarten through second grade, students begin communicating multiple designs in the form of diagrams and sketches. By third to fifth grade, students move from mere drawings to actually testing out their designs to see how they perform under different conditions. Students then use this data to make improvements. As in Kindergarten through second grade, students practice the idea that communication of designs with peers is an essential part of the design process. In this sixth grade unit, students move towards using data from testing solutions to inform improvements, focusing on the idea that parts of different solutions can be used to make an even better solution. In later units and grade levels, students will focus on another PE associated with this DCI (not shown below), which asks students to use systematic processes to evaluate solutions for how well they meet criteria and constraints. At the different grade levels, students engage in a variety of different science and engineering practices: Developing Models in K-2, Designing Solutions (specifically comparing solutions) in 3-5, and Analyzing and Interpreting Data and Engaging in Argument From Evidence in 6-8. This is representative of the different practices students are engaging with, described above.

The following is the progression of the Performance Expectations for this DCI:

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| **K-2-ETS1-2** | Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem. |
| **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. |
| **MS-ETS1-3** | Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success. |

ETS1.C. Optimizing the Design Solution: In Kindergarten through second grade, students begin to understand that because there are always multiple solutions to a problem, it is useful to compare and test designs. Students in third through fifth grade take this skill and use findings from those tests to determine which solution best meets criteria and constraints that they identified through ETS1.A. In accordance with the progression students follow in middle school for ETS1.B, students in this eighth grade unit move towards using data and analysis to identify best characteristics and inform a new and better solution. Thus, it makes sense that at all grade levels, students focus on Science and Engineering Practices related to testing and analyzing: Planning and Carrying Out Investigations and Analyzing and Interpreting Data. At the eighth grade level, students will take these skills further to develop models that will generate data to test ideas about designed systems (PE not shown below).

The following is the progression of the Performance Expectations for this DCI:

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| **K-2-ETS1-3** | Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs. |
| **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. |
| **MS-ETS1-3** | Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success. |