Middle School Phenomenon Model Course 2 – Bundle 2
Climate Diversity

This is the second bundle of the Middle School Phenomenon Model Course 2. Each bundle has connections to the other bundles in the course, as shown in the Course Flowchart.

Bundle 2 Question: This bundle is assembled to address the question "what causes climates to be so different across the Earth?"

Summary

The bundle organizes performance expectations with a focus on helping students build understanding of causes of diverse climates. Instruction developed from this bundle should always maintain the three-dimensional nature of the standards, and recognize that instruction is not limited to the practices and concepts directly linked with any of the bundle performance expectations.

Connections between bundle DCIs

Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things (ESS2.D as in MS-ESS2-6). The ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time, and globally redistributing it through ocean currents (ESS2.D as in MS-ESS2-6). Additionally, the complex patterns of the changes and the movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns (ESS2.C as in MS-ESS2-5). And because these patterns are so complex, weather can only be predicted probabilistically (ESS2.D as in MS-ESS2-5). However, mapping the history of natural hazards in a region combined with an understanding of related geological forces, can help forecast the locations and likelihoods of future events (ESS3.B as in MS-ESS3-2). Mitigating effects from natural hazards requires effective communication methods, such as using digitized signals as a more reliable way to encode and transmit information (PS4.C as in MS-PS4-3).

The engineering design idea that 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 (ETS1.A as in MS-ETS1-1) could connect to several science concepts, such as using digitized signals as a more reliable way to encode and transmit information (PS4.C as in MS-PS4-3) or mapping the history of natural hazards in a region to help forecast the locations and likelihoods of future hazardous natural events (ESS3.B as in MS-ESS3-2). Connections could be made through engineering design tasks such as asking questions to determine the necessary criteria and constraints, including limitations, that are needed for either a communication system to warn people of an upcoming storm, or construction of storm shelters to mitigate adverse effects of hazardous events.

Additionally, the engineering design idea that there are systematic processes for evaluating solutions with respect to how well a design solution meets the criteria and constraints of a problem (ETS1.B as in MS-ETS1-2) could connect to several science concepts, such as using digitized signals as a more reliable way to encode and transmit information (PS4.C as in MS-PS4-3) or mapping the history of natural hazards in a region to help forecast the locations and likelihoods of future hazardous natural events (ESS3.B as in MS-ESS3-2). Connections could be made through engineering design tasks such as engaging in argument from evidence about either how well a warning system communicates information or how well a computer model meets the criteria and constraints for predicting future hazardous events.

Bundle Science and Engineering Practices

Instruction leading to this bundle of PEs will help students build toward proficiency in elements of the practices of defining problems (MS-ETS1-1), developing and using models (MS-ESS2-6), planning and carrying out investigations (MS-ESS2-5), analyzing and interpreting data (MS-ESS3-2), engaging in argumentation (MS-ETS1-2), and obtaining, evaluating, and communicating information (MS-PS4-3). Many other practice elements can be used in instruction.

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Bundle Crosscutting Concepts Instruction leading to this bundle of PEs will help students build toward proficiency in elements of the crosscutting concepts of Patterns (MS-ESS3-2), Cause and Effect (MS-ESS2-5), Systems and System Models (MS-ESS2-6), and Structure and Function (MS-PS4-3). Many other crosscutting concept elements can be used in instruction. *All instruction should be three-dimensional.*	
Performance Expectations	MS-PS4-3. **Integrate qualitative scientific and technical information to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals.** [Clarification Statement: Emphasis is on a basic understanding that waves can be used for communication purposes. Examples could include using fiber optic cable to transmit light pulses, radio wave pulses in wifi devices, and conversion of stored binary patterns to make sound or text on a computer screen.] [Assessment Boundary: Assessment does not include binary counting. Assessment does not include the specific mechanism of any given device.] MS-ESS2-5. **Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions.** [Clarification Statement: Emphasis is on how air masses flow from regions of high pressure to low pressure, causing weather (defined by temperature, pressure, humidity, precipitation, and wind) at a fixed location to change over time, and how sudden changes in weather can result when different air masses collide. Emphasis is on how weather can be predicted within probabilistic ranges. Examples of data can be provided to students (such as weather maps, diagrams, and visualizations) or obtained through laboratory experiments (such as with condensation).] [Assessment Boundary: Assessment does not include recalling the names of cloud types or weather symbols used on weather maps or the reported diagrams from weather stations.] 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.** [Clarification Statement: Emphasis is on how patterns vary by latitude, altitude, and geographic land distribution. Emphasis of atmospheric circulation is on the sunlight-driven latitudinal banding, the Coriolis effect, and resulting prevailing winds; emphasis of ocean circulation is on the transfer of heat by the global ocean convection cycle, which is constrained by the Coriolis effect and the outlines of continents. Examples of models can be diagrams, maps and globes, or digital representations.] [Assessment Boundary: Assessment does not include the dynamics of the Coriolis effect.] MS-ESS3-2. **Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.** [Clarification Statement: Emphasis is on how some natural hazards, such as volcanic eruptions and severe weather, are preceded by phenomena that allow for reliable predictions, but others, such as earthquakes, occur suddenly and with no notice, and thus are not yet predictable. Examples of natural hazards can be taken from interior processes (such as earthquakes and volcanic eruptions), surface processes (such as mass wasting and tsunamis), or severe weather events (such as hurricanes, tornadoes, and floods). Examples of data can include the locations, magnitudes, and frequencies of the natural hazards. Examples of technologies can be global (such as satellite systems to monitor hurricanes or forest fires) or local (such as building basements in tornado-prone regions or reservoirs to mitigate droughts).] 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.** MS-ETS1-2. **Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.**
Example Phenomena	Thunderstorms come more often in the afternoon than in the morning. Hurricanes cause more damage to human property than do thunderstorms.

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Additional Practices Building to the PEs	**Asking Questions and Defining Problems** • Ask questions to identify and/or clarify evidence and/or the premise(s) of an argument. Students could *ask questions to identify and/or clarify evidence* [about how] ***mapping the history of natural hazards in a region can help forecast the locations and likelihoods of future events***. MS-ESS3-2 **Developing and Using Models** • Develop or modify a model—based on evidence—to match what happens if a variable or component of a system is changed. Students could *develop or modify a model based on evidence to match what happens if* [the] ***way to encode and transmit information*** [is changed from analog to] ***digitized signals***. MS-PS4-3 **Planning and Carrying Out Investigations** • Evaluate the accuracy of various methods for collecting data. Students could *evaluate the accuracy of various methods for collecting data* [about] ***the history of natural hazards in a region*** [to] ***help forecast the locations and likelihoods of future events***. MS-ESS3-2 **Analyzing and Interpreting Data** • Use graphical displays of large data sets to identify temporal and spatial relationships. Students could *use graphical displays of large data sets to identify temporal and spatial relationships* [between] ***the ocean*** [and] ***weather*** [due to the ocean's ability to] ***absorb energy from the sun, release it over time, and globally redistribute it through ocean currents***. MS-ESS2-6 **Using Mathematical and Computational Thinking** • Use digital tools (e.g., computers) to analyze very large data sets for patterns and trends. Students could *use digital tools to analyze very large data sets for patterns and trends* [related to] ***the ocean absorbing energy from the sun, releasing it over time, and globally redistributing it through ocean currents***. MS-ESS2-6 **Constructing Explanations and Designing Solutions** • Apply scientific ideas, principles, and/or evidence to construct, revise and/or use an explanation for real-world phenomena, examples, or events. Students could *apply scientific ideas, and evidence to construct an explanation* [of how] ***landforms*** [affect] ***the movement of water in the atmosphere.*** MS-ESS2-5 **Engaging in Argument from Evidence** • Make an oral or written argument that supports or refutes the advertised performance of a device, process, or system, based on empirical evidence concerning whether or not the technology meets relevant criteria and constraints. Students could *make an oral argument that refutes the advertised performance of a device based on empirical evidence for whether or not the technology meets relevant criteria and constraints* [for] ***more reliably encoding and transmitting information.*** MS-PS4-3

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Additional Practices Building to the PEs (Continued)	**Obtaining, Evaluating, and Communicating Information** • Gather, read, synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence. Students could *gather, read, and synthesize information from multiple sources* [about] ***the complex patterns of the changes and movement of water in the atmosphere*** *and assess the credibility and accuracy of each publication*. MS-ESS2-5
Additional Crosscutting Concepts Building to the PEs	**Patterns** • Patterns can be used to identify cause and effect relationships. Students could construct an argument from evidence for how ***mapping the history of natural hazards in a region, combined with an understanding of related geologic forces*** [can be used to] *identify patterns in cause and effect relationships*, [helping to] ***forecast the locations and likelihoods of future events***. MS-ESS3-2 **Systems and System Models** • Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems. Students could develop a model [for how] *systems may interact with other systems, may have sub-systems, and may be part of a larger complex systems*, [including as evidence that] ***weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things***. MS-ESS2-6 **Stability and Change** • Stability might be disturbed either by sudden events or gradual changes that accumulate over time. Students could analyze and interpret data on how *stability* ***of local weather patterns*** *might be disturbed either by sudden events* [due to] ***winds, landforms, and ocean temperatures and currents***. MS-ESS2-5
Additional Connections to Nature of Science	**Scientific Investigations Use a Variety of Methods** • Science investigations use a variety of methods and tools to make measurements and observations. Students could ask questions about why *science investigations use a variety of methods and tools to make measurements and observations* [to] ***map the history of natural hazards in a region***. MS-ESS3-2 **Science is a Human Endeavor (CCC):** • Scientists and engineers are guided by habits of mind such as intellectual honesty, tolerance of ambiguity, skepticism and openness to new ideas. Students could construct an argument from evidence for how *scientists' habits of mind such as intellectual honesty, tolerance of ambiguity, skepticism and openness to new ideas* [affect their understanding of how] ***weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things***. MS-ESS2-6

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MS-PS4-3 Waves and Their Applications in Technologies for Information Transfer

Students who demonstrate understanding can:

MS-PS4-3. Integrate qualitative scientific and technical information to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals. [Clarification Statement: Emphasis is on a basic understanding that waves can be used for communication purposes. Examples could include using fiber optic cable to transmit light pulses, radio wave pulses in wifi devices, and conversion of stored binary patterns to make sound or text on a computer screen.] [*Assessment Boundary: Assessment does not include binary counting. Assessment does not include the specific mechanism of any given device.*]

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

Obtaining, Evaluating, and Communicating Information

Obtaining, evaluating, and communicating information in 6-8 builds on K-5 and progresses to evaluating the merit and validity of ideas and methods.

- Integrate qualitative scientific and technical information in written text with that contained in media and visual displays to clarify claims and findings.

Disciplinary Core Ideas

PS4.C: Information Technologies and Instrumentation

- Digitized signals (sent as wave pulses) are a more reliable way to encode and transmit information.

Crosscutting Concepts

Structure and Function

- Structures can be designed to serve particular functions.

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Connections to Engineering, Technology, and Applications of Science

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

- Technologies extend the measurement, exploration, modeling, and computational capacity of scientific investigations.

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Connections to Nature of Science

Science is a Human Endeavor

- Advances in technology influence the progress of science and science has influenced advances in technology.

Observable features of the student performance by the end of the course:				
1	Obtaining information			
	a	Given materials from a variety of different types of sources of information (e.g., texts, graphical, video, digital), students gather evidence sufficient to support a claim about a phenomenon that includes the idea that using waves to carry digital signals is a more reliable way to encode and transmit information than using waves to carry analog signals.		
2	Evaluating information			
	a	Students combine the relevant information (from multiple sources) to support the claim by describing*:		
		i.	Specific features that make digital transmission of signals more reliable than analog transmission of signals, including that, when in digitized form, information can be:	
			1.	Recorded reliably.
			2.	Stored for future recovery.
			3.	Transmitted over long distances without significant degradation.
		ii.	At least one technology that uses digital encoding and transmission of information. Students should describe* how the digitization of that technology has advanced science and scientific investigations (e.g., digital probes, including thermometers and pH probes; audio recordings).	

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MS-ESS2-5 Earth's Systems

Students who demonstrate understanding can:

MS-ESS2-5. **Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions.** [Clarification Statement: Emphasis is on how air masses flow from regions of high pressure to low pressure, causing weather (defined by temperature, pressure, humidity, precipitation, and wind) at a fixed location to change over time, and how sudden changes in weather can result when different air masses collide. Emphasis is on how weather can be predicted within probabilistic ranges. Examples of data can be provided to students (such as weather maps, diagrams, and visualizations) or obtained through laboratory experiments (such as with condensation).] [*Assessment Boundary: Assessment does not include recalling the names of cloud types or weather symbols used on weather maps or the reported diagrams from weather stations.*]

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
Planning and Carrying Out Investigations Planning and carrying out investigations in 6-8 builds on K-5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or solutions. • Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions.	**ESS2.C: The Roles of Water in Earth's Surface Processes** • The complex patterns of the changes and the movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns. **ESS2.D: Weather and Climate** • Because these patterns are so complex, weather can only be predicted probabilistically.	**Cause and Effect** • Cause and effect relationships may be used to predict phenomena in natural or designed systems.

Observable features of the student performance by the end of the course:			
1	Identifying the phenomenon under investigation		
	a	From the given investigation plan, students describe* the phenomenon under investigation, which includes the relationships between air mass interactions and weather conditions.	
	b	Students identify the purpose of the investigation, which includes providing evidence to answer questions about how motions and complex interactions of air masses result in changes in weather conditions [note: expectations of students regarding mechanisms are limited to relationships between patterns of activity of air masses and changes in weather].	
2	Identifying the evidence to address the purpose of the investigation		
	a	From a given investigation plan, students describe* the data to be collected and the evidence to be derived from the data that would indicate relationships between air mass movement and changes in weather, including:	
		i.	Patterns in weather conditions in a specific area (e.g., temperature, air pressure, humidity, wind speed) over time.
		ii.	The relationship between the distribution and movement of air masses and landforms, ocean temperatures, and currents.

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		iii. The relationship between observed, large-scale weather patterns and the location or movement of air masses, including patterns that develop between air masses (e.g., cold fronts may be characterized by thunderstorms).
	b	Students describe* how the evidence to be collected will be relevant to determining the relationship between patterns of activity of air masses and changes in weather conditions.
	c	Students describe* that because weather patterns are so complex and have multiple causes, weather can be predicted only probabilistically.
3	Planning the investigation	
	a	Students describe* the tools and methods used in the investigation, including how they are relevant to the purpose of the investigation.
4	Collecting the data	
	a	According to the provided investigation plan, students make observations and record data, either firsthand and/or from professional weather monitoring services.

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MS-ESS2-6 Earth's Systems

Students who demonstrate understanding can:

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. [Clarification Statement: Emphasis is on how patterns vary by latitude, altitude, and geographic land distribution. Emphasis of atmospheric circulation is on the sunlight-driven latitudinal banding, the Coriolis effect, and resulting prevailing winds; emphasis of ocean circulation is on the transfer of heat by the global ocean convection cycle, which is constrained by the Coriolis effect and the outlines of continents. Examples of models can be diagrams, maps and globes, or digital representations.] [*Assessment Boundary: Assessment does not include the dynamics of the Coriolis effect.*]

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

Developing and Using Models
Modeling in 6–8 builds on K–5 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.

Disciplinary Core Ideas

ESS2.C: The Roles of Water in Earth's Surface Processes

- Variations in density due to variations in temperature and salinity drive a global pattern of interconnected ocean currents.

ESS2.D: Weather and Climate

- Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns.
- The ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time, and globally redistributing it through ocean currents.

Crosscutting Concepts

Systems and System Models

- Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems.

Observable features of the student performance by the end of the course:			
1	Components of the model		
	a	To make sense of a phenomenon, students develop a model in which they identify the relevant components of the system, with inputs and outputs, including:	
		i.	The rotating Earth.
		ii.	The atmosphere.
		iii.	The ocean, including the relative rate of thermal energy transfer of water compared to land or air.
		iv.	Continents and the distribution of landforms on the surface of Earth.
		v.	Global distribution of ice.
		vi.	Distribution of living things.
		vii.	Energy.
			1. Radiation from the sun as an input.
			2. Thermal energy that exists in the atmosphere, water, land, and ice (as represented by temperature).

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2	Relationships		
	a	In the model, students identify and describe* the relationships between components of the system, including:	
		i.	Differences in the distribution of solar energy and temperature changes, including:
			1. Higher latitudes receive less solar energy per unit of area than do lower latitudes, resulting in temperature differences based on latitude.
			2. Smaller temperature changes tend to occur in oceans than on land in the same amount of time.
			3. In general, areas at higher elevations have lower average temperatures than do areas at lower elevations.
			4. Features on the Earth's surface, such as the amount of solar energy reflected back into the atmosphere or the absorption of solar energy by living things, affect the amount of solar energy transferred into heat energy.
		ii.	Motion of ocean waters and air masses (matter):
			1. Fluid matter (i.e., air, water) flows from areas of higher density to areas of lower density (due to temperature or salinity). The density of a fluid can vary for several different reasons (e.g., changes in salinity and temperature of water can each cause changes in density). Differences in salinity and temperature can, therefore, cause fluids to move vertically and, as a result of vertical movement, also horizontally because of density differences.
		iii.	Factors affecting the motion of wind and currents:
			1. The Earth's rotation causes oceanic and atmospheric flows to curve when viewed from the rotating surface of Earth (Coriolis force).
			2. The geographical distribution of land limits where ocean currents can flow.
			3. Landforms affect atmospheric flows (e.g., mountains deflect wind and/or force it to higher elevation).
		iv.	Thermal energy transfer:
			1. Thermal energy moves from areas of high temperature to areas of lower temperature either through the movement of matter, via radiation, or via conduction of heat from warmer objects to cooler objects.
			2. Absorbing or releasing thermal energy produces a more rapid change in temperature on land compared to in water.
			3. Absorbing or releasing thermal energy produces a more rapid change in temperature in the atmosphere compared to either on land or in water so the atmosphere is warmed or cooled by being in contact with land or the ocean.
3	Connections		
	a	Students use the model to describe*:	
		i.	The general latitudinal pattern in climate (higher average annual temperatures near the equator and lower average annual temperatures at higher latitudes) caused by more direct light (greater energy per unit of area) at the equator (more solar energy) and less direct light at the poles (less solar energy).
		ii.	The general latitudinal pattern of drier and wetter climates caused by the shift in the amount of air moisture during precipitation from rising moisture-rich air and the sinking of dry air.
		iii.	The pattern of differing climates in continental areas as compared to the oceans. Because water can absorb more solar energy for every degree change in temperature compared to land, there is a greater and more rapid temperature change on land than in the ocean. At the centers of landmasses, this leads to conditions typical of continental climate patterns.
		iv.	The pattern that climates near large water bodies, such as marine coasts, have comparatively smaller changes in temperature relative to the center of the landmass. Land near the oceans can exchange thermal energy through the air, resulting in smaller changes in temperature. At the edges of landmasses, this leads to marine climates.
		v.	The pattern that climates at higher altitudes have lower temperatures than climates at lower altitudes. Because of the direct relationship between temperature and pressure, given the same amount of thermal energy, air at lower pressures (higher altitudes) will have lower temperatures than air at higher pressures (lower altitudes).

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		vi. Regional patterns of climate (e.g., temperature or moisture) related to a specific pattern of water or air circulation, including the role of the following in contributing to the climate pattern:
		1. Air or water moving from areas of high temperature, density, and/or salinity to areas of low temperature, density, and/or salinity.
		2. The Earth's rotation, which affects atmospheric and oceanic circulation.
		3. The transfer of thermal energy with the movement of matter.
		4. The presence of landforms (e.g., the rain shadow effect).
	b	Students use the model to describe* the role of each of its components in producing a given regional climate.

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MS-ESS3-2 Earth and Human Activity

Students who demonstrate understanding can:

MS-ESS3-2. Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects. [Clarification Statement: Emphasis is on how some natural hazards, such as volcanic eruptions and severe weather, are preceded by phenomena that allow for reliable predictions, but others, such as earthquakes, occur suddenly and with no notice, and thus are not yet predictable. Examples of natural hazards can be taken from interior processes (such as earthquakes and volcanic eruptions), surface processes (such as mass wasting and tsunamis), or severe weather events (such as hurricanes, tornadoes, and floods). Examples of data can include the locations, magnitudes, and frequencies of the natural hazards. Examples of technologies can be global (such as satellite systems to monitor hurricanes or forest fires) or local (such as building basements in tornado-prone regions or reservoirs to mitigate droughts).]

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

Analyzing and Interpreting Data
Analyzing data in 6–8 builds on K–5 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.

Disciplinary Core Ideas

ESS3.B: Natural Hazards

- 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.

Crosscutting Concepts

Patterns

- Graphs, charts, and images can be used to identify patterns in data.

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Connections to Engineering, Technology, and Applications of Science

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

- The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time.

Observable features of the student performance by the end of the course:			
1	Organizing data		
	a	Students organize given data that represent the type of natural hazard event and features associated with that type of event, including the location, magnitude, frequency, and any associated precursor event or geologic forces.	
	b	Students organize data in a way that facilitates analysis and interpretation.	
	c	Students describe* what each dataset represents.	
2	Identifying relationships		
	a	Students analyze data to identify and describe* patterns in the datasets, including:	
		i.	The location of natural hazard events relative to geographic and/or geologic features.
		ii.	Frequency of natural hazard events.
		iii.	Severity of natural hazard events.
		iv.	Types of damage caused by natural hazard events.

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		v. Location or timing of features and phenomena (e.g., aftershocks, flash floods) associated with natural hazard events.
	b	Students describe* similarities and differences among identified patterns.
3	Interpreting data	
	a	Students use the analyzed data to describe*:
		i. Areas that are susceptible to the natural hazard events, including areas designated as at the greatest and least risk for severe events.
		ii. How frequently areas, including areas experiencing the highest and lowest frequency of events, are at risk.
		iii. What type of damage each area is at risk of during a given natural hazard event.
		iv. What features, if any, occur before a given natural hazard event that can be used to predict the occurrence of the natural hazard event and when and where they can be observed.
	b	Using patterns in the data, students make a forecast for the potential of a natural hazard event to affect an area in the future, including information on frequency and/or probability of event occurrence; how severe the event is likely to be; where the event is most likely to cause the most damage; and what events, if any, are likely to precede the event.
	c	Students give at least three examples of the technologies that engineers have developed to mitigate the effects of natural hazards (e.g., the design of buildings and bridges to resist earthquakes, warning sirens for tsunamis, storm shelters for tornados, levees along rivers to prevent flooding).

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MS-ETS1-1 Engineering Design

Students who demonstrate understanding can:

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.

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

Asking Questions and Defining Problems
Asking questions and defining problems in grades 6–8 builds on grades K–5 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.

Disciplinary Core Ideas

ETS1.A: Defining and Delimiting Engineering Problems

- 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.

Crosscutting Concepts

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

- All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment.
- The uses of technologies and limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions.

Observable features of the student performance by the end of the course:			
1	Identifying the problem to be solved		
	a	Students describe* a problem that can be solved through the development of an object, tool, process, or system.	
2	Defining the process or system boundaries and the components of the process or system		
	a	Students identify the system in which the problem is embedded, including the major components and relationships in the system and its boundaries, to clarify what is and is not part of the problem. In their definition of the system, students include:	
		i.	Which individuals or groups need this problem to be solved.
		ii.	The needs that must be met by solving the problem.
		iii.	Scientific issues that are relevant to the problem.
		iv.	Potential societal and environmental impacts of solutions.
		v.	The relative importance of the various issues and components of the process or system.
3	Defining criteria and constraints		
	a	Students define criteria that must be taken into account in the solution that:	
		i.	Meet the needs of the individuals or groups who may be affected by the problem (including defining who will be the target of the solution).
		ii.	Enable comparisons among different solutions, including quantitative considerations when appropriate.
	b	Students define constraints that must be taken into account in the solution, including:	
		i.	Time, materials, and costs.
		ii.	Scientific or other issues that are relevant to the problem.
		iii.	Needs and desires of the individuals or groups involved that may limit acceptable solutions.
		iv.	Safety considerations.
		v.	Potential effect(s) on other individuals or groups.
		vi.	Potential negative environmental effects of possible solutions or failure to solve the problem.

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MS-ETS1-2 Engineering Design

Students who demonstrate understanding can:

MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they 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
Engaging in Argument from Evidence Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world. • Evaluate competing design solutions based on jointly developed and agreed-upon design criteria.	**ETS1.B: Developing Possible Solutions** • There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem.	

Observable features of the student performance by the end of the course:			
1	Identifying the given design solution and associated claims and evidence		
	a	Students identify the given supported design solution.	
	b	Students identify scientific knowledge related to the problem and each proposed solution.	
	c	Students identify how each solution would solve the problem.	
2	Identifying additional evidence		
	a	Students identify and describe* additional evidence necessary for their evaluation, including:	
		i.	Knowledge of how similar problems have been solved in the past.
		ii.	Evidence of possible societal and environmental impacts of each proposed solution.
	b	Students collaboratively define and describe* criteria and constraints for the evaluation of the design solution.	
3	Evaluating and critiquing evidence		
	a	Students use a systematic method (e.g., a decision matrix) to identify the strengths and weaknesses of each solution. In their evaluation, students:	
		i.	Evaluate each solution against each criterion and constraint.
		ii.	Compare solutions based on the results of their performance against the defined criteria and constraints.
	b	Students use the evidence and reasoning to make a claim about the relative effectiveness of each proposed solution based on the strengths and weaknesses of each.	

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