Middle School Phenomenon Model Course III - Bundle 2
Life Affects Life

This is the second bundle of the Middle School Phenomenon Model Course III. 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 "How can people influence other organisms?"

Summary

The bundle organizes performance expectations with a focus on helping students build understanding of ways that humans have influenced organisms both directly (through artificial selection) and indirectly (by affecting their environments). 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

Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations (LS2.C as in MS-LS2-4). When ecosystem conditions change, organisms must respond appropriately. To do so, they use sense receptors that respond to inputs (electromagnetic, mechanical, chemical), transmitting them as signals that travel along nerve cells to the brain. The signals are then processed in the brain, resulting in immediate behaviors or memories (LS1.D as in MS-LS1-8).

When organisms cannot respond appropriately to changes in environmental conditions, the species may change over time via adaptation by natural selection. Traits that support successful survival and reproduction in the new environment become more common; those that do not become less common (LS4.C as in MS-LS2-6). Humans can also influence certain characteristics of organisms by selective breeding via artificial selection. One can choose desired parental traits determined by genes, which are then passed on to offspring (LS4.B as in MS-LS4-5).

One factor that changes ecosystems over time is climate change. Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth's mean surface temperature (global warming). Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior and on applying that knowledge wisely in decisions and activities (ESS3.D as found in MS-ESS3-5).

The engineering design ideas that there are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem (ETS1.B as in MS-ETS1-3), and that a solution needs to be tested, and then modified on the basis of the test results, in order to improve it (ETS1.B as in MS-ETS1-4) could connect to many different science ideas, including that disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations (LS2.C as in MS-LS2-4), and that in artificial selection, humans have the capacity to influence certain characteristics of organisms by selective breeding (LS4.B as in MS-LS4-5). Connections could be made by having students evaluate different solutions systematically, whether solutions for reducing disruptions to ecosystems or for breeding strains of plants with the desired characteristics. In either case, students could identify any modifications that need to be made to the solution in order to improve it.

Bundle Science and Engineering Practices

Instruction leading to this bundle of PEs will help students build toward proficiency in elements of the practices of asking questions (MS-ESS3-5), developing and using models (MS-ETS1-4), analyzing and interpreting data (MS-ETS1-3), using mathematics and computational thinking (MS-LS4-6), engaging in argument from evidence (MS-LS2-4), and obtaining, evaluating, and communicating information (MS-LS1-8 and MS-LS4-5). 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 Cause and Effect (MS-LS1-8, MS-LS4-5, and MS-LS4-6) and Stability and Change (MS-LS2-4 and MS-ESS3-5). Many other crosscutting concept elements can be used in instruction. *All instruction should be three-dimensional.*	
Performance Expectations MS-LS4-6 is partially assessable.	MS-LS1-8 **Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.** [Assessment Boundary: Assessment does not include mechanisms for the transmission of this information.] MS-LS2-4. **Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.** [Clarification Statement: Emphasis is on recognizing patterns in data and making warranted inferences about changes in populations, and on evaluating empirical evidence supporting arguments about changes to ecosystems.] MS-LS4-5. **Gather and synthesize information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms.** [Clarification Statement: Emphasis is on synthesizing information from reliable sources about the influence of humans on genetic outcomes in artificial selection (such as genetic modification, animal husbandry, gene therapy); and, on the impacts these technologies have on society as well as the technologies leading to these scientific discoveries.] MS-LS4-6. **Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time.** [Clarification Statement: Emphasis is on using mathematical models, probability statements, and proportional reasoning to support explanations of trends in changes to populations over time.] [*Assessment Boundary: Assessment does not include Hardy Weinberg calculations.*] MS-ESS3-5. **Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.** [Clarification Statement: Examples of factors include human activities (such as fossil fuel combustion, cement production, and agricultural activity) and natural processes (such as changes in incoming solar radiation or volcanic activity). Examples of evidence can include tables, graphs, and maps of global and regional temperatures, atmospheric levels of gases such as carbon dioxide and methane, and the rates of human activities. Emphasis is on the major role that human activities play in causing the rise in global temperatures.] 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.** MS-ETS1-4 **Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.**
Example Phenomena	Cabbage, broccoli, and Brussels sprouts are all the same species. Fields near diversion dams grow crops even with very little rainfall.
Additional Practices Building to the PEs	**Asking Questions and Defining Problems** • Ask questions to determine relationships between independent and dependent variables and relationships in models. Students could *ask questions to determine the* [effects of] ***a disruption to a biological component of an ecosystem***. MS-LS2-4

Additional Practices Building to the PEs (Continued)	**Developing and Using Models** • Evaluate limitations of a model for a proposed object or tool. Students could *evaluate limitations of a model for a proposed tool* [that could help] ***reduce human vulnerability to whatever climate changes occur***. MS-ESS3-5 **Planning and Carrying Out Investigations** • Collect data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions. Students could *collect data to serve as the basis for evidence to answer scientific questions* [about whether] ***traits that support successful survival and reproduction in a new environment become more common***. MS-LS4-6 **Analyzing and Interpreting Data** • Consider limitations of data analysis (e.g., measurement error), and/or seek to improve precision and accuracy of data with better technological tools and methods (e.g., multiple trials). Students could *consider limitations of data analysis* [when analyzing whether] ***signals processed in the brain result in immediate behavior or memories***. MS-LS1-8 **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* ***in the current rise in Earth's mean surface temperature***. MS-ESS3-5 **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, principles, and evidence to construct an explanation* [that] ***humans influence certain characteristics of organisms by selective breeding***. MS-LS4-5 **Engaging in Argument from Evidence** • Respectfully provide and receive critiques about one's explanations, procedures, models and questions by citing relevant evidence and posing and responding to questions that elicit pertinent elaboration and detail. Students could *respectfully provide critiques about models by citing relevant evidence and posing questions that elicit pertinent elaboration and detail* [about how] ***the distribution of traits in a population changes.*** *MS-LS4-6*

Additional Practices Building to the PEs (Continued)	**Obtaining, Evaluating, and Communicating Information** • Critically read scientific texts adapted for classroom use to determine the central ideas and/or obtain scientific and/or technical information to describe patterns in and/or evidence about the natural and designed world. Students could *critically read scientific texts to determine evidence* [that] ***disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations.*** MS-LS2-4
Additional Crosscutting Concepts Building to the PEs	**Cause and Effect** • Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation. Students could analyze data to *classify relationships* [between] ***disruptions to a physical component of an ecosystem*** [and] ***shifts in its populations*** *as either causal or correlational*. MS-LS2-4 **Structure and Function** • Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among its parts; therefore, complex natural and designed structures/systems can be analyzed to determine how they function. Students could analyze ***sense receptors*** *to describe how their function depends on the shapes and relationships among their parts*. MS-LS1-8 **Stability and Change** • Stability might be disturbed either by sudden events or gradual changes that accumulate over time. Students could analyze data to compare the effects of *sudden events or gradual changes* in ***the distribution of traits in a population.*** MS-LS4-6
Additional Connections to Nature of Science	**Scientific Investigations us a Variety of Methods** • Science depends on evaluating proposed explanations. Students could construct an argument for why *science depends on evaluating proposed explanations*, [including for how] ***the distribution of traits in a population changes***. MS-LS4-6 **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** • Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation. Students could construct an argument [for how the assumption] *that events in natural systems occur in consistent patterns that are understandable through measurement and observation* [affects their understanding that] ***parental traits are determined by genes, which are then passed on to offspring***. MS-LS4-5

MS-LS1-8 From Molecules to Organisms: Structures and Processes

Students who demonstrate understanding can:

MS-LS1-8. **Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.** [*Assessment Boundary: Assessment does not include mechanisms for the transmission of this information.*]

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
Obtaining, Evaluating, and Communicating Information Obtaining, evaluating, and communicating information in 6-8 builds on K-5 experiences and progresses to evaluating the merit and validity of ideas and methods. • Gather, read, and 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.	**LS1.D: Information Processing** • Each sense receptor responds to different inputs (electromagnetic, mechanical, chemical), transmitting them as signals that travel along nerve cells to the brain. The signals are then processed in the brain, resulting in immediate behaviors or memories.	**Cause and Effect** • Cause and effect relationships may be used to predict phenomena in natural systems.

Observable features of the student performance by the end of the course:			
1	Obtaining information		
	a	Students gather and synthesize information from at least two sources (e.g., text, media, visual displays, data) about a phenomenon that includes the relationship between sensory receptors and the storage and usage of sensory information by organisms. Students gather information about:	
		i.	Different types of sensory receptors and the types of inputs to which they respond (e.g., electromagnetic, mechanical, chemical stimuli).
		ii.	Sensory information transmission along nerve cells from receptors to the brain.
		iii.	Sensory information processing by the brain as:
			1. Memories (i.e., stored information).
			2. Immediate behavioral responses (i.e., immediate use).
	b	Students gather sufficient information to provide evidence that illustrates the causal relationships between information received by sensory receptors and behavior, both immediate and over longer time scales (e.g., a loud noise processed via auditory receptors may cause an animal to startle immediately or may be encoded as a memory, which can later be used to help the animal react appropriately in similar situations).	
2	Evaluating information		
	a	Students evaluate the information based on:	
		i.	The credibility, accuracy, and possible bias of each publication and the methods used to generate and collect the evidence.
		ii.	The ability of the information to provide evidence that supports or does not support the idea that sensory receptors send signals to the brain, resulting in immediate behavioral changes or stored memories.
		iii.	Whether the information is sufficient to allow prediction of the response of an organism to different stimuli based on cause and effect relationships between the responses of sensory receptors and behavioral responses.

MS-LS2-4 Ecosystems: Interactions, Energy, and Dynamics

Students who demonstrate understanding can:

MS-LS2-4. **Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.** [Clarification Statement: Emphasis is on recognizing patterns in data and making warranted inferences about changes in populations, and on evaluating empirical evidence supporting arguments about changes to ecosystems.]

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

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(s).

- Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.

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Connections to Nature of Science

Scientific Knowledge is Based on Empirical Evidence

- Science disciplines share common rules of obtaining and evaluating empirical evidence.

Disciplinary Core Ideas

LS2.C: Ecosystem Dynamics, Functioning, and Resilience

- Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations.

Crosscutting Concepts

Stability and Change

- Small changes in one part of a system might cause large changes in another part.

Observable features of the student performance by the end of the course:		
1	Supported claims	
	a	Students make a claim to be supported about a given explanation or model for a phenomenon. In their claim, students include the idea that changes to physical or biological components of an ecosystem can affect the populations living there.
2	Identifying scientific evidence	
	a	Students identify and describe* the given evidence (e.g., evidence from data, scientific literature) needed for supporting the claim, including evidence about:
		i. Changes in the physical or biological components of an ecosystem, including the magnitude of the changes (e.g., data about rainfall, fires, predator removal, species introduction).
		ii. Changes in the populations of an ecosystem, including the magnitude of the changes (e.g., changes in population size, types of species present, and relative prevalence of a species within the ecosystem).
		iii. Evidence of causal and correlational relationships between changes in the components of an ecosystem with the changes in populations.
	b	Students use multiple valid and reliable sources of evidence.
3	Evaluating and critiquing the evidence	
	a	Students evaluate the given evidence, identifying the necessary and sufficient evidence for supporting the claim.
	b	Students identify alternative interpretations of the evidence and describe* why the evidence supports the student's claim.
4	Reasoning and synthesis	
	a	Students use reasoning to connect the appropriate evidence to the claim and construct an oral or written argument about the causal relationship between physical and biological components of an

		ecosystem and changes in organism populations, based on patterns in the evidence. In the argument, students describe* a chain of reasoning that includes:	
		i.	Specific changes in the physical or biological components of an ecosystem cause changes that can affect the survival and reproductive likelihood of organisms within that ecosystem (e.g., scarcity of food or the elimination of a predator will alter the survival and reproductive probability of some organisms).
		ii.	Factors that affect the survival and reproduction of organisms can cause changes in the populations of those organisms.
		iii.	Patterns in the evidence suggest that many different types of changes (e.g., changes in multiple types of physical and biological components) are correlated with changes in organism populations.
		iv.	Several consistent correlational patterns, along with the understanding of specific causal relationships between changes in the components of an ecosystem and changes in the survival and reproduction of organisms, suggest that many changes in physical or biological components of ecosystems can cause changes in populations of organisms.
		v.	Some small changes in physical or biological components of an ecosystem are associated with large changes in a population, suggesting that small changes in one component of an ecosystem can cause large changes in another component.

MS-LS4-5 Biological Evolution: Unity and Diversity

Students who demonstrate understanding can:

MS-LS4-5. Gather and synthesize information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms. [Clarification Statement: Emphasis is on synthesizing information from reliable sources about the influence of humans on genetic outcomes in artificial selection (such as genetic modification, animal husbandry, gene therapy); and, on the impacts these technologies have on society as well as the technologies leading to these scientific discoveries.]

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 experiences and progresses to evaluating the merit and validity of ideas and methods.

- Gather, read, and 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.

Disciplinary Core Ideas

LS4.B: Natural Selection

- In *artificial* selection, humans have the capacity to influence certain characteristics of organisms by selective breeding. One can choose desired parental traits determined by genes, which are then passed on to offspring.

Crosscutting Concepts

Cause and Effect

- Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.

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Connections to Engineering, Technology, and Applications of Science

Interdependence of Science, Engineering, and Technology

- Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineered systems.

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Connections to Nature of Science

Science Addresses Questions About the Natural and Material World

- Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes.

Observable features of the student performance by the end of the course:		
1	Obtaining information	
	a	Students gather information about at least two technologies that have changed the way humans influence the inheritance of desired traits in plants and animals through artificial selection by choosing desired parental traits determined by genes, which are then often passed on to offspring. Examples could include gene therapy, genetic modification, and selective breeding of plants and animals.
	b	Students use at least two appropriate and reliable sources of information for investigating each technology.
2	Evaluating information	
	a	Students assess the credibility, accuracy, and possible bias of each publication and method used in the information they gather.
	b	Students use their knowledge of artificial selection and additional sources to describe* how the information they gather is or is not supported by evidence.

	c	Students synthesize the information from multiple sources to provide examples of how technologies have changed the ways that humans are able to influence the inheritance of desired traits in organisms.
	d	Students use the information to identify and describe* how a better understanding of cause-and-effect relationships in how traits occur in organisms has led to advances in technology that provide a higher probability of being able to influence the inheritance of desired traits in organisms.

MS-LS4-6 Biological Evolution: Unity and Diversity

Students who demonstrate understanding can:

MS-LS4-6. Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time. [Clarification Statement: Emphasis is on using mathematical models, probability statements, and proportional reasoning to support explanations of trends in changes to populations over time.] [*Assessment Boundary: Assessment does not include Hardy Weinberg calculations.*]

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 Mathematical and computational thinking in 6–8 builds on K–5 experiences and progresses to identifying patterns in large data sets and using mathematical concepts to support explanations and arguments. • Use mathematical representations to support scientific conclusions and design solutions.	**LS4.C: Adaptation** • Adaptation by natural selection acting over generations is one important process by which species change over time in response to changes in environmental conditions. Traits that support successful survival and reproduction in the new environment become more common; those that do not become less common. Thus, the distribution of traits in a population changes.	**Cause and Effect** • Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.

Observable features of the student performance by the end of the course:			
1	Representation		
	a	Students identify the explanations for phenomena that they will support, which include:	
		i.	Characteristics of a species change over time (i.e., over generations) through adaptation by natural selection in response to changes in environmental conditions.
		ii.	Traits that better support survival and reproduction in a new environment become more common within a population within that environment.
		iii.	Traits that do not support survival and reproduction as well become less common within a population in that environment.
		iv.	When environmental shifts are too extreme, populations do not have time to adapt and may become extinct.
	b	From given mathematical and/or computational representations of phenomena, students identify the relevant components, including:	
		i.	Population changes (e.g., trends, averages, histograms, graphs, spreadsheets) gathered from historical data or simulations.
		ii.	The distribution of specific traits over time from data and/or simulations.
		iii.	Environmental conditions (e.g., climate, resource availability) over time from data and/or simulations.
2	Mathematical Modeling		
	a	Students use the given mathematical and/or computational representations (e.g., trends, averages, histograms, graphs, spreadsheets) of the phenomenon to identify relationships in the data and/or simulations, including:	
		i.	Changes and trends over time in the distribution of traits within a population.
		ii.	Multiple cause-and-effect relationships between environmental conditions and natural selection in a population.
		iii.	The increases or decreases of some traits within a population can have more than one environmental cause.
3	Analysis		
	a	Students analyze the mathematical and/or computational representations to provide and describe* evidence that distributions of traits in populations change over time in response to changes in	

		environmental conditions. Students synthesize their analysis together with scientific information about natural selection to describe* that species adapt through natural selection. This results in changes in the distribution of traits within a population and in the probability that any given organism will carry a particular trait.
	b	Students use the analysis of the mathematical and/or computational representations (including proportional reasoning) as evidence to support the explanations that:
		i. Through natural selection, traits that better support survival and reproduction are more common in a population than those traits that are less effective.
		ii. Populations are not always able to adapt and survive because adaptation by natural selection occurs over generations.
	c	Based on their analysis, students describe* that because there are multiple cause-and-effect relationships contributing to the phenomenon, for each different cause it is not possible to predict with 100% certainty what will happen.

MS-ESS3-5 Earth and Human Activity

Students who demonstrate understanding can:

MS-ESS3-5. Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century. [Clarification Statement: Examples of factors include human activities (such as fossil fuel combustion, cement production, and agricultural activity) and natural processes (such as changes in incoming solar radiation or volcanic activity). Examples of evidence can include tables, graphs, and maps of global and regional temperatures, atmospheric levels of gases such as carbon dioxide and methane, and the rates of human activities. Emphasis is on the major role that human activities play in causing the rise in global temperatures.]

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
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. • Ask questions to identify and clarify evidence of an argument.	**ESS3.D: Global Climate Change** • Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth's mean surface temperature (global warming). Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior and on applying that knowledge wisely in decisions and activities.	**Stability and Change** • Stability might be disturbed either by sudden events or gradual changes that accumulate over time.

Observable features of the student performance by the end of the course:			
1	Addressing phenomena of the natural world		
	a	Students examine a given claim and the given supporting evidence as a basis for formulating questions. Students ask questions that would identify and clarify the evidence, including:	
		i.	The relevant ways in which natural processes and/or human activities may have affected the patterns of change in global temperatures over the past century.
		ii.	The influence of natural processes and/or human activities on a gradual or sudden change in global temperatures in natural systems (e.g., glaciers and arctic ice, and plant and animal seasonal movements and life cycle activities).
		iii.	The influence of natural processes and/or human activities on changes in the concentration of carbon dioxide and other greenhouse gases in the atmosphere over the past century.
2	Identifying the scientific nature of the question		
	a	Students questions can be answered by examining evidence for:	
		i.	Patterns in data that connect natural processes and human activities to changes in global temperatures over the past century.
		ii.	Patterns in data that connect the changes in natural processes and/or human activities related to greenhouse gas production to changes in the concentrations of carbon dioxide and other greenhouse gases in the atmosphere.

MS-ETS1-3 Engineering Design

Students who demonstrate understanding can:

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.

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 Analyzing data in 6–8 builds on K–5 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.	**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. • Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. **ETS1.C: Optimizing the Design Solution** • 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.	

Observable features of the student performance by the end of the course:		
1	Organizing data	
	a	Students organize given data (e.g., via tables, charts, or graphs) from tests intended to determine the effectiveness of three or more alternative solutions to a problem.
2	Identifying relationships	
	a	Students use appropriate analysis techniques (e.g., qualitative or quantitative analysis; basic statistical techniques of data and error analysis) to analyze the data and identify relationships within the datasets, including relationships between the design solutions and the given criteria and constraints.
3	Interpreting data	
	a	Students use the analyzed data to identify evidence of similarities and differences in features of the solutions.
	b	Based on the analyzed data, students make a claim for which characteristics of each design best meet the given criteria and constraints.
	c	Students use the analyzed data to identify the best features in each design that can be compiled into a new (improved) redesigned solution.

MS-ETS1-4 Engineering Design

Students who demonstrate understanding can:

MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

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 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 a model to generate data to test ideas about designed systems, including those representing inputs and outputs.	**ETS1.B: Developing Possible Solutions** • A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. • Models of all kinds are important for testing solutions. **ETS1.C: Optimizing the Design Solution** • 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.	

Observable features of the student performance by the end of the course:			
1	Components of the model		
	a	Students develop a model in which they identify the components relevant to testing ideas about the designed system, including:	
		i.	The given problem being solved, including criteria and constraints.
		ii.	The components of the given proposed solution (e.g., object, tools, or process), including inputs and outputs of the designed system.
2	Relationships		
	a	Students identify and describe* the relationships between components, including:	
		i.	The relationships between each component of the proposed solution and the functionality of the solution.
		ii.	The relationship between the problem being solved and the proposed solution.
		iii.	The relationship between each of the components of the given proposed solution and the problem being solved.
		iv.	The relationship between the data generated by the model and the functioning of the proposed solution.
3	Connections		
	a	Students use the model to generate data representing the functioning of the given proposed solution and each of its iterations as components of the model are modified.	
	b	Students identify the limitations of the model with regards to representing the proposed solution.	
	c	Students describe* how the data generated by the model, along with criteria and constraints that the proposed solution must meet, can be used to optimize the design solution through iterative testing and modification.	