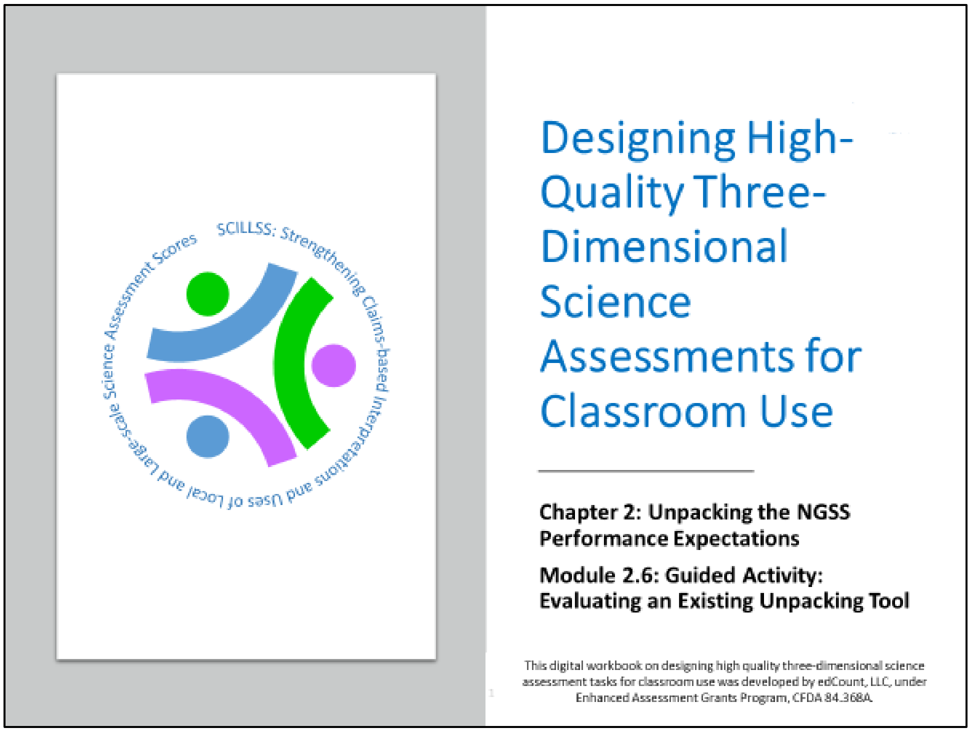
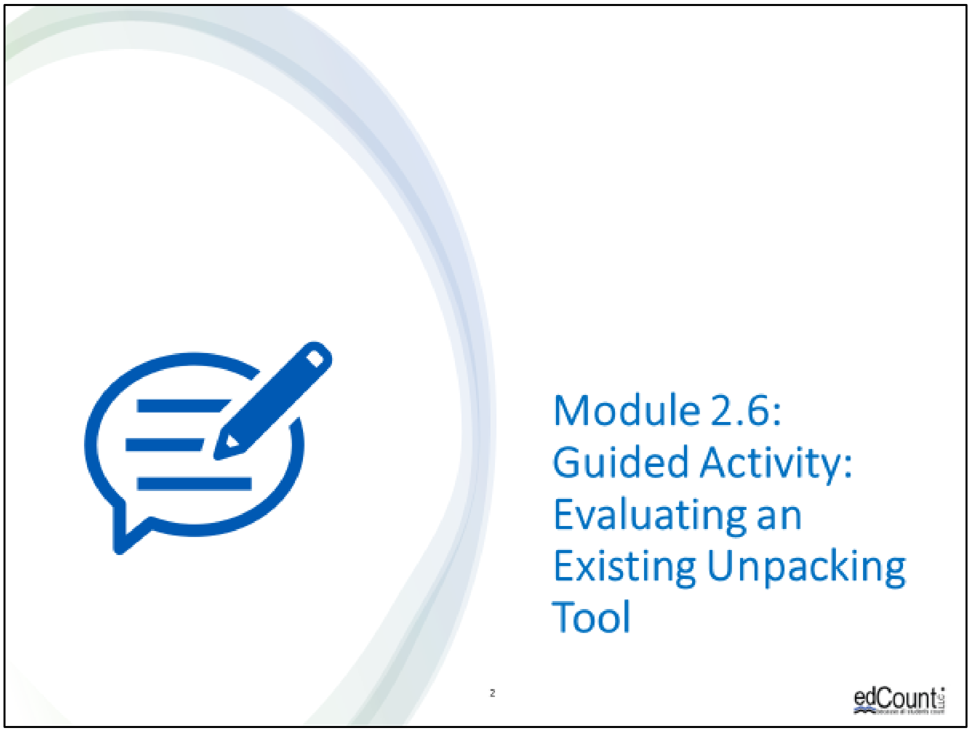
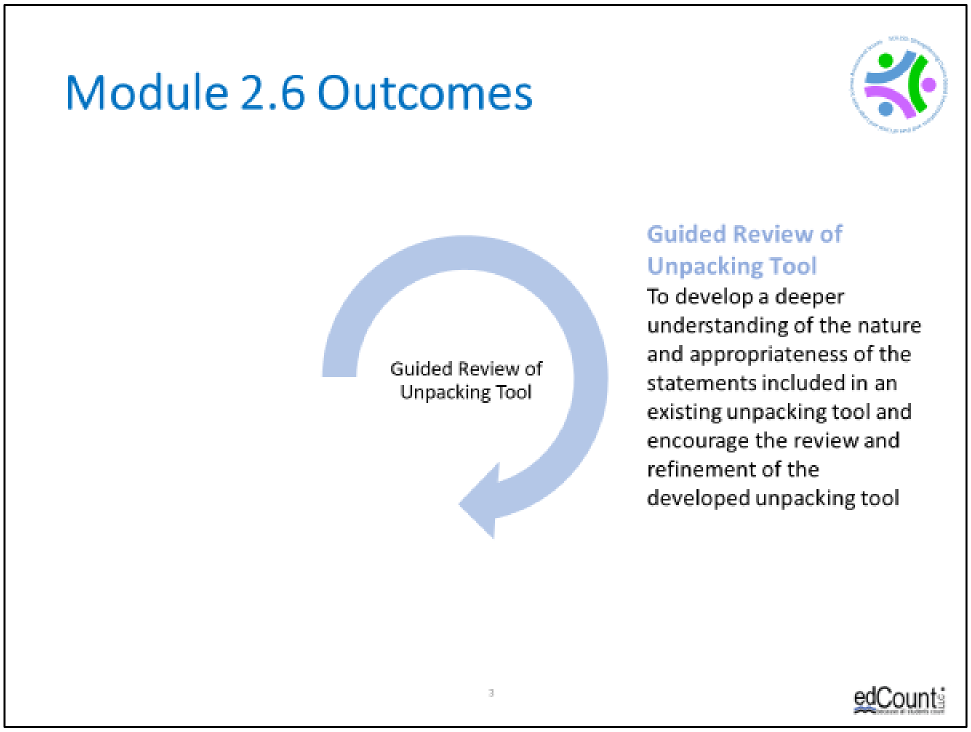


Welcome to the second of four chapters in a digital workbook on designing high-quality three-dimensional science assessment tasks for classroom use. This workbook is intended to help educators design and evaluate high-quality classroom science assessment tasks that provide meaningful information about what students know and can do in science.

This digital workbook was developed by edCount, LLC, under the US Department of Education's Enhanced Assessment Grants Program, CFDA 84.368A.

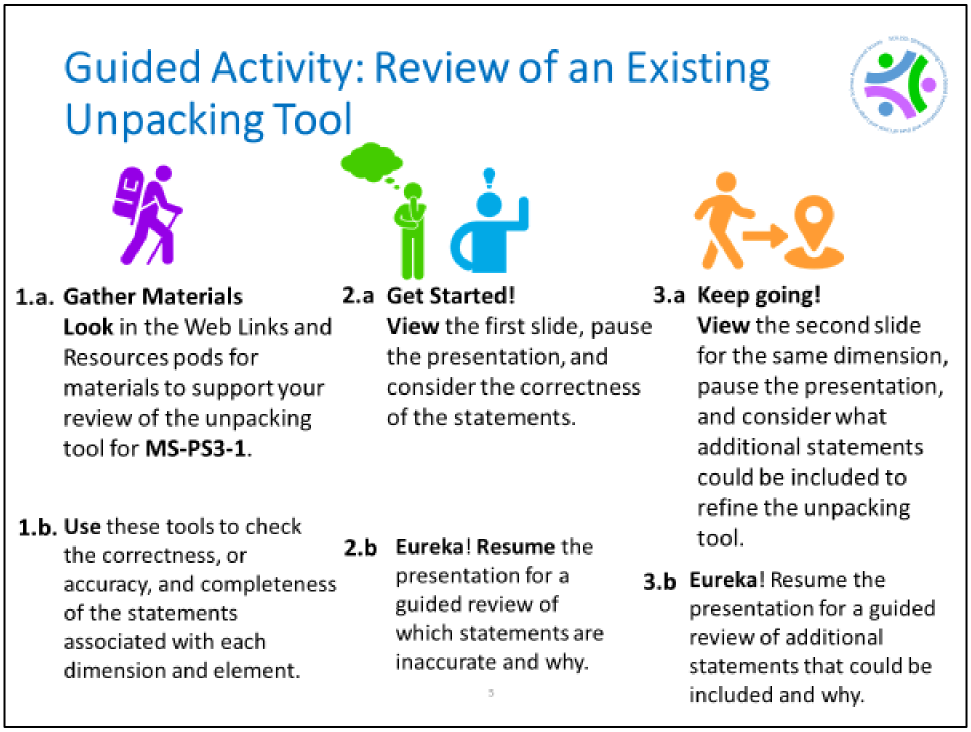


Chapter 2 of this workbook includes a series of six modules. Together, these six modules provide an in-depth exploration of the first phase of principled assessment design: development of the unpacking tool. In this chapter, we describe how to systematically unpack a performance expectation or indicator into its multiple components to develop a clear and deep understanding of each dimension and the boundaries of what can be assessed. We provide opportunities for you to engage in interactive activities and explore and use our design template to complete your own unpacking of a three-dimensional science standard.



In Module 2.6, we invite you to participate in a guided activity to evaluate an existing unpacking tool. You will have an opportunity to critically analyze statements of the key aspects, prior knowledge, and relationships between the CCC and SEP to determine whether they are appropriate and well-aligned to the selected PE. By engaging in this activity, our intent is to show why it is important to and how you can benefit from continually reviewing and refining the unpacking tool.

Now that you are well acquainted with the purpose and elements of the unpacking tool and the available reference materials in the Web Links and Resources pods, let's begin a guided activity. In this activity, you will first analyze statements and determine their correctness in relationship to a middle school PE and then consider additional statements to refine and further develop an unpacking tool.



As discussed in previous modules, the unpacking tool is a design tool that helps educators gain a deep understanding of the dimensions of the PE and identify its assessable components.

In this activity, we provide you with an opportunity to use the *Framework* and the NGSS resources to apply your skill at refining an unpacking tool for the middle school PE, *MS-PS3-1. Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.*

Alright. Here are the steps to complete this guided activity. First, access the materials in the Web Links and Resources pods to support your review of the provided unpacking tool for MS-PS3-1.

Once you've accessed the resources, view the first slide, and pause the presentation to consider the correctness and accuracy of the provided statements. After you analyze the statements, resume the presentation for guidance about which statements are incorrect. Consider the explanations provided for why the statements are incorrect.

Next, view the second slide, which is populated with the correct statements for the same dimension, and pause the presentation to consider and determine what additional statements could be added to the key aspects or prior knowledge elements. After you determine what additional statements could be added, resume the presentation for suggested additional statements and explanations for these additions.

Repeat these steps for each dimension of the PE. For each dimension, we provide two slides with statements from the unpacking tool for you to consider.

Please note that you can obtain directions for completing this guided activity in the Resources pod titled, “Guided Activity—Review of a Developed Unpacking Tool.”

Let’s get started.

Grade:	Middle School
NGSS	**MS-PS3-1.** Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object. [Clarification Statement: Emphasis is on descriptive relationships between kinetic energy and mass separately from kinetic energy and speed. Examples could include riding a bicycle at different speeds, rolling different sizes of rocks downhill, and getting hit by a wiffle ball versus a tennis ball.]
	Science and Engineering Practices (SEP)
	SEP: Analyzing and Interpreting Data ~~Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics, and/or computation.~~ Construct and interpret graphical displays of data to identify linear and nonlinear relationships.
Key Aspects	• ~~Collect data to identify linear and nonlinear relationships.~~ • Graphing, analyzing, and interpreting data. • Use graphical displays of data to identify linear relationships. • Use graphical displays of data to identify nonlinear relationships. • Use large data sets to identify nonlinear relationships. • ~~Identify accurate sources of data for a given design problem.~~ • Analyze data to refine a problem statement or the design of a proposed object, tool, or process.
Prior Knowledge	• Create and read graphs. • Analyze and interpret data to provide evidence for phenomena. • ~~Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success.~~ • ~~Consider limitations of data analysis (e.g., measurement error, sample selection) when analyzing and interpreting data.~~ • Compare and contrast data collected by different groups in order to discuss similarities and differences in their findings.

On this first slide associated with the SEP, *Analyzing and Interpreting Data*, consider if each statement indicated for the SEP, key aspects, and prior knowledge is correct or incorrect. Pause the presentation to read and consider each statement. Then, resume the presentation to see the incorrect statements, which will be indicated in red and struck through. An explanation is provided as to why each statement is incorrect.

Under the SEP, *Analyzing and Interpreting Data*, the statement, *Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics, and/or computation,* is incorrect. This statement is associated with the SEP, *Analyzing and Interpreting Data;* however, it aligns with grades 3–5 expectations. Don't be misled by common words that may be found in the PE and the SEP. Be sure to confirm that the PE code of the selected PE is shown in parentheses behind the SEP indicated in the foundation box for the selected PE.

For the key aspects, two statements exceed what students should be able to do and are incorrectly indicated for this middle school PE. The statement, *Collect data to identify linear and nonlinear relationships,* exceeds the expectation of the PE. The PE indicates that students construct and interpret graphical displays of data, but students are *not* expected to collect the data. Similarly, the statement, *Identify accurate sources of data for a given design problem,* exceeds what students are expected to do. Students are expected to construct and interpret graphical displays of data but are *not* expected to identify accurate sources of that data.

With respect to the unpacking tool element, prior knowledge, two statements are incorrect. When examining Appendix F. Science and Engineering Practices, the statements, *Analyze data* *to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success* and *Consider limitations of data analysis (e.g., measurement error, sample selection) when analyzing and interpreting data,* are both associated with grades 9–12. They describe expectations of what students can do when they analyze and interpret data as their understanding becomes more sophisticated. These statements are above grade level and are outside of the boundaries for assessment.

Grade:	Middle School
NGSS	**MS-PS3-1.** Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object. [Clarification Statement: Emphasis is on descriptive relationships between kinetic energy and mass separately from kinetic energy and speed. Examples could include riding a bicycle at different speeds, rolling different sizes of rocks downhill, and getting hit by a wiffle ball versus a tennis ball.]
	Science and Engineering Practices (SEP) **SEP: Analyzing and Interpreting Data** Construct and interpret graphical displays of data to identify linear and nonlinear relationships.
Key Aspects	• Graphing, analyzing, and interpreting data. • Use graphical displays of data to identify linear relationships. • Use graphical displays of data to identify nonlinear relationships. • Use large data sets to identify linear relationships. • Use large data sets to identify nonlinear relationships. • Analyze and interpret data to identify relationships with regard to a phenomenon using graphical displays. • Analyze data to refine a problem statement or the design of a proposed object, tool, or process.
Prior Knowledge	• Create and read graphs. • Analyze and interpret data to provide evidence for phenomena. • Represent data in tables and/or various graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships. • Compare and contrast data collected by different groups in order to discuss similarities and differences in their findings.

On this second slide associated with the same SEP, the unpacking tool is populated with only correct statements. Consider how well the statements address the multiple aspects of the SEP to determine what additional statements could be added to the key aspects and prior knowledge. Pause the presentation to consider and determine additional statements. Then, resume the presentation for suggested additional statements and explanations for these additions.

For the key aspects, the first added statement, *Use large data sets to identify linear relationships*, is an appropriate addition as it indicates “linear” relationships which is aligned to the SEP. Note that the SEP indicates both “linear” and “nonlinear” relationships. The second added statement, *Analyze and interpret data to identify relationships with regard to a phenomenon using graphical displays*, is an appropriate addition as provided graphical displays of data need to be analyzed to interpret these data. It relates using the data to make sense of phenomena. This statement focuses on analyzing and interpreting data with respect to “phenomenon,” whereas the last key aspect refers to analyzing data in the context of a design problem.

With respect to the unpacking tool element, prior knowledge, the added statement, *Represent data in tables and/or various graphical displays (bar graphs, pictographs, and/or pie charts) to reveal patterns that indicate relationships*, is an appropriate addition given an examination of the SEP, *Analyzing and Interpreting Data* in Appendix F. For grades 3–5, it indicates a prerequisite skill that students are able to represent data in tables and/or various graphical displays (bar graphs, pictographs, and/or pie charts) to reveal patterns that indicate relationships.

Grade:	Middle School
NGSS	**MS-PS3-1.** Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object. [Clarification Statement: Emphasis is on descriptive relationships between kinetic energy and mass separately from kinetic energy and speed. Examples could include riding a bicycle at different speeds, rolling different sizes of rocks downhill, and getting hit by a wiffle ball versus a tennis ball.]
	Disciplinary Core Ideas (DCI)
	DCI: PS3.A: Definitions of Energy Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed. ~~Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present.~~
Key Aspects	• The kinetic energy of an object is proportional to its mass. • When an object is in motion, the energy it contains is called kinetic energy. • The relationship between kinetic energy and mass is a linear proportional relationship. • ~~The relationship between kinetic energy and speed is a linear proportional relationship.~~ • Kinetic energy is associated with the speed and the mass of an object. • The potential energy objects have is dependent on their relative positions. • ~~Energy changes to and from each type can only be tracked through physical interactions.~~ • The proportional relationship between kinetic energy and the mass and speed of an object.
Prior Knowledge	• Objects have mass. • Objects in motion contain energy. • ~~The total energy within a system is conserved. Energy transfer within and between systems can be described and predicted in terms of energy associated with the motion or configuration of particles (objects).~~ • Motion is the change in an object's location over time. • Objects can change motion, slow, stop, or change direction. • Force causes change in the motion or direction of an object. • Lighter objects require less energy to move than heavy objects. • The motion of an object is dependent on the force applied to it. • The motion energy (kinetic energy) of an object increases as it travels faster.

On this first slide associated with the DCI, *Definitions of Energy*, consider if each statement indicated for the DCI, key aspects, and prior knowledge is correct or incorrect. Pause the presentation to read and consider each statement. Then, resume the presentation to see the incorrect statements, which will be indicated in red and struck through. An explanation is provided as to why each statement is incorrect.

Under the DCI, *Definitions of Energy*, the statement, *Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present,* is incorrect. This statement is associated with two different PEs, MS-PS3-3 and MS-PS3-4, as shown in the topic arrangement. Be sure to confirm that the PE code of the selected PE is shown in parentheses behind the DCI indicated in the foundation box.

For the key aspects, two statements exceed what students should be able to do and are incorrect. The statement, *The relationship between kinetic energy and speed is a linear proportional relationship,* contains inaccurate science. The relationship between kinetic energy and speed is a *nonlinear (square) proportional relationship* and NOT *a linear proportional relationship.* Also, the statement, *Energy changes to and from each type can only be tracked through physical interactions,* contains inaccurate science. Energy changes to and from each type can be tracked through physical *or* chemical interactions.

With respect to the unpacking tool element, prior knowledge, one statement is incorrect. The statement, *The total energy within a system is conserved. Energy transfer within and between* *systems can be described and predicted in terms of energy associated with the motion or configuration of particles (objects),* exceeds the expectation of the PE. It describes more sophisticated core ideas from the 9–12 grade band than what middle school students should know. These core ideas are above grade level and are outside of the boundaries for assessment.

Grade:	Middle School	
NGSS	**MS-PS3-1.** Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object. [Clarification Statement: Emphasis is on descriptive relationships between kinetic energy and mass separately from kinetic energy and speed. Examples could include riding a bicycle at different speeds, rolling different sizes of rocks downhill, and getting hit by a wiffle ball versus a tennis ball.]	
	Disciplinary Core Ideas (DCI)	
	DCI: PS3.A: Definitions of Energy Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed.	
Key Aspects	• The kinetic energy of an object is proportional to its mass. • When an object is in motion, the energy it contains is called kinetic energy. • The kinetic energy of an object increases if either the mass or the speed of the object increases or if both increase. • The relationship between kinetic energy and mass is a linear proportional relationship. • The relationship between kinetic energy and speed is a nonlinear (square) proportional relationship. • Kinetic energy decreases by a factor of four as the speed of the object is cut in half. • Kinetic energy is associated with the speed and the mass of an object. • The potential energy objects have is dependent on their relative positions. • The proportional relationship between kinetic energy and the mass and speed of an object.	
Prior Knowledge	• Objects have mass. • Objects in motion contain energy. • Motion is the change in an object's location over time. • The faster an object moves, the more energy it has. • Objects can change motion, slow, stop, or change direction. • Force causes change in the motion or direction of an object. • Energy can be moved from place to place by moving objects. • Lighter objects require less energy to move than heavy objects. • The motion of an object is dependent on the force applied to it. • The motion energy (kinetic energy) of an object increases as it travels faster.	

On this second slide associated with the same DCI, the unpacking tool is populated with only correct statements. Consider how well the statements address the multiple aspects of the DCI to determine what additional statements could be added to the key aspects and prior knowledge. Pause the presentation to consider and determine additional statements. Then, resume the presentation for suggested additional statements and explanations for these additions.

For the key aspects, the first added statement, *The kinetic energy of an object increases if either the mass or the speed of the object increases or if both increase,* is an appropriate addition as the DCI references the proportional relationship between mass and the speed of moving objects. The second added statement, *Kinetic energy decreases by a factor of four as the speed of the objects is cut in half,* is found in the evidence statements associated with this PE under the observable features related to interpreting data.

With respect to the unpacking tool element, prior knowledge, the two added statements, *The faster an object moves, the more energy it has* and *Energy can be moved from place to place by moving objects,* are appropriate additions given an examination of the 3–5 grade band statements associated with the DCI, *Definitions of Energy* in Appendix E. Students should have an understanding of core ideas related to the speed at which an object moves and the energy it has as well as that energy can be moved from place to place by moving objects.

Grade:	Middle School
NGSS	**MS-PS3-1.** Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object. [Clarification Statement: Emphasis is on descriptive relationships between kinetic energy and mass separately from kinetic energy and speed. Examples could include riding a bicycle at different speeds, rolling different sizes of rocks downhill, and getting hit by a wiffle ball versus a tennis ball.]
	Crosscutting Concepts (CCC)
	CCC: Scale, Proportion, and Quantity 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.
Key Aspects	• Speed is the ratio of distance traveled to time taken. • Ratio and proportionality provide information about the magnitude of properties.
Relationships to SEPs	• Taking measurements of structures and phenomena are usually obtained, analyzed, and interpreted quantitatively. • Mathematics is essential in both science and engineering.

On this first slide associated with the CCC, *Scale, Proportion, and Quantity*, consider if each statement indicated for the CCC, key aspects, and relationship to the SEPs is correct or incorrect. Pause the presentation to read and consider each statement. Then, resume the presentation to see the incorrect statements, which will be indicated in red and struck through. An explanation is provided as to why each statement is incorrect.

Careful review of the statements associated with the CCC, *Scale, Proportion, and Quantity*, indicates that ALL of the statements are correct, and none are struck through or removed. These statements, as indicated, align to the middle school resources used to confirm these statements.

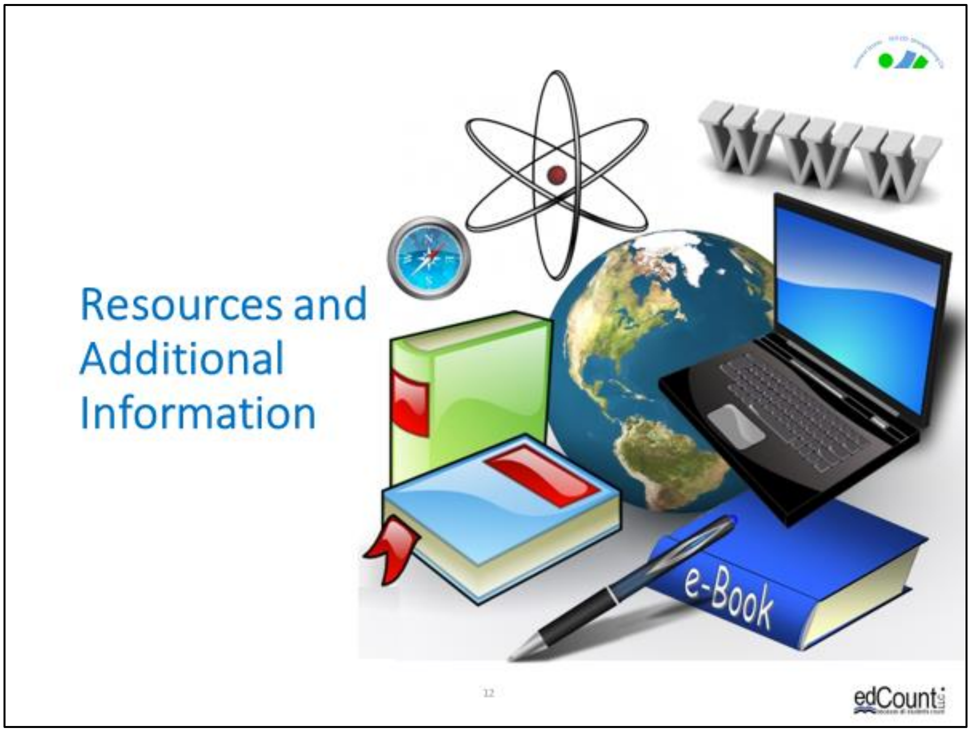
Grade:	Middle School
NGSS	**MS-PS3-1.** Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object. [Clarification Statement: Emphasis is on descriptive relationships between kinetic energy and mass separately from kinetic energy and speed. Examples could include riding a bicycle at different speeds, rolling different sizes of rocks downhill, and getting hit by a wiffle ball versus a tennis ball.]
	Crosscutting Concepts (CCC)
	CCC: Scale, Proportion, and Quantity 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.
Key Aspects	• Speed is the ratio of distance traveled to time taken. • Ratio and proportionality provide information about the magnitude of properties. • Ratio and proportionality provide information about the magnitude of processes.
Relationships to SEPs	• Taking measurements of structures and phenomena are usually obtained, analyzed, and interpreted quantitatively. • Mathematics is essential in both science and engineering. • Different aspects of nature change at different rates with changes in scale, and so the relationships among them change, too.

On this second slide associated with the same CCC, the unpacking tool is populated with only correct statements. Consider how well the statements address the multiple aspects of the CCC to determine what additional statements could be added to the key aspects and relationships to SEPs. Pause the presentation to consider and determine additional statements. Then, resume the presentation for suggested additional statements and explanations for these additions.

For the key aspects, the first added statement, *Ratio and proportionality provide information about the magnitude of processes*, is an appropriate addition as the CCC references both properties and processes with respect to the types of information that are obtained when considering proportional relationships among different types of quantities. This provides a good example of the importance of a careful review of the CCC to ensure that all aspects are articulated and represented in the key aspects.

For the relationships to SEPs, the added statement, *Different aspects of nature change at different rates with changes in scale, and so the relationships among them change, too*, is also an appropriate addition. It is stated in the *Framework* in the general description of this CCC, *Scale, Proportion, and Quantity* (The *Framework*, NRC, 2012, p. 89).

Congratulations, and thank you for completing this guided activity. We hope that you found it useful and that your familiarity with the unpacking tool and use of the resources have been enhanced.

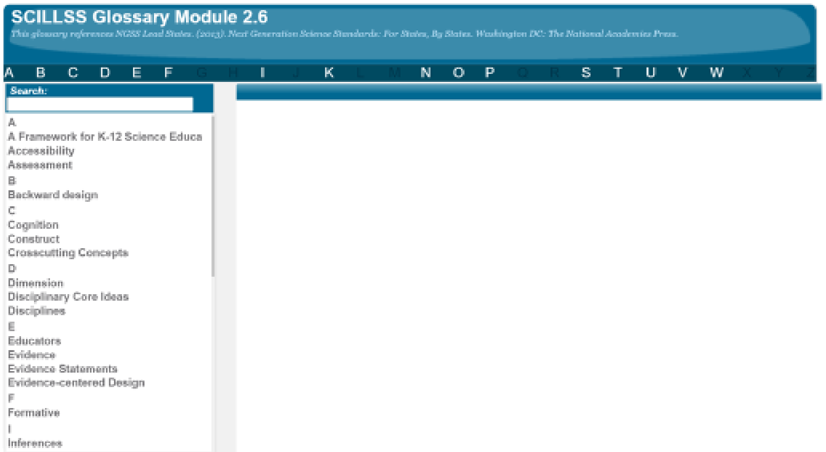


Finally, we offer additional resources that may be helpful to anyone interested in learning more about the concepts presented in this chapter. A glossary of terms and our reference list follow.

Thank you for your engagement in this second chapter of the SCILLSS digital workbook on designing high-quality three-dimensional science assessment tasks for classroom use.

SCILLSS Glossary

Please refer to the SCILLSS Glossary for operational definitions of terms used.



13

Resources

In the Web Links pod, you can find the following resources:

- A Framework for K-12 Science Education
- Next Generation Science Standards
- NGSS Evidence Statements
- Appendix E: Disciplinary Core Idea Progressions
- Appendix F: Science and Engineering Practices
- Appendix G: Crosscutting Concepts

In the Resources pod, you can find the following resources:

- Guided Activity: Review of an Existing Unpacking Tool

14

References

National Research Council. (2012). *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. Washington, DC: The National Academies Press. https://doi.org/10.17226/13165.