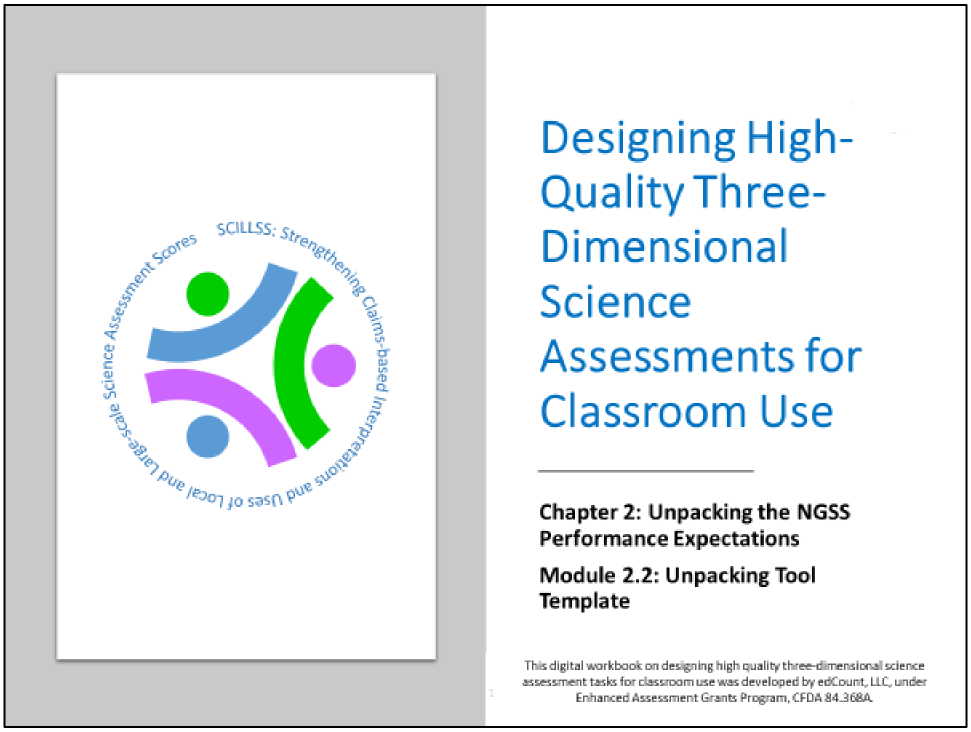
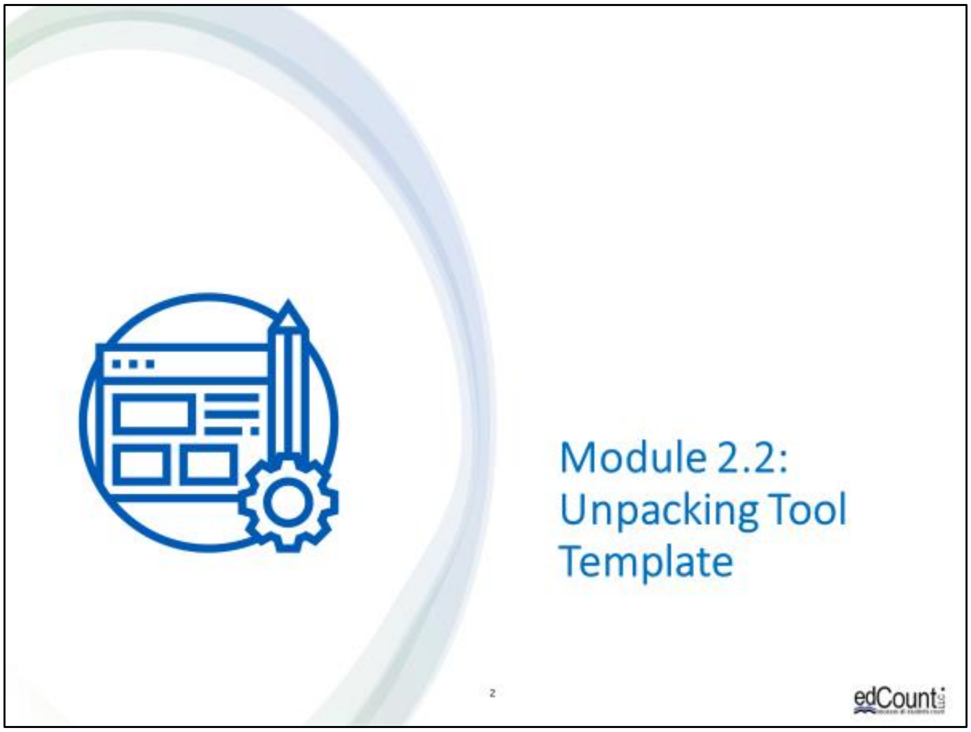


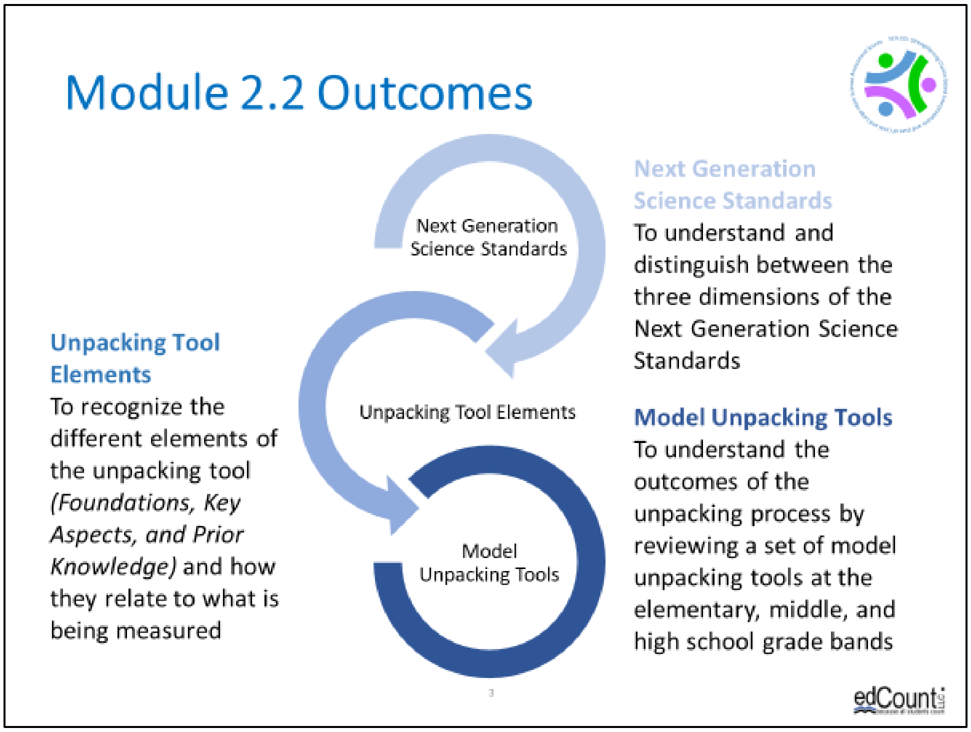
Welcome to the second of four chapters in a digital workbook on designing high-quality three-dimensional science assessment tasks for classroom use. This workbook is intended to help educators design and evaluate high-quality classroom science assessment tasks that provide meaningful information about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

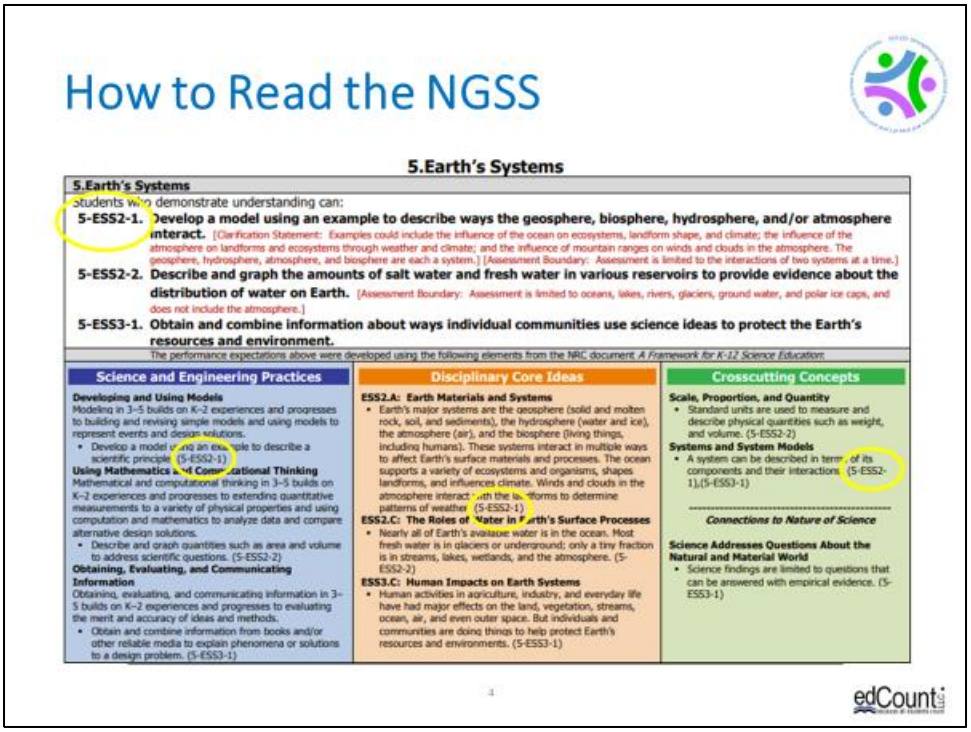
In this module, we take a deeper dive into the three dimensions of the Next Generation Science Standards and explore elements of the unpacking tool. We provide completed unpacking tools at the elementary, middle, and high school grade bands to illustrate the outcomes of the unpacking process. In later modules, we offer resources, key strategies, and guiding questions for completing the unpacking process.



A Framework for K–12 Science Education is designed to help realize a vision for education in the sciences and engineering in which students, over multiple years of school, actively engage in scientific and engineering practices and apply crosscutting concepts to deepen their understanding of the core ideas in these fields (the *Framework*, NRC, 2012, pp. 8-9). To facilitate students' learning, the dimensions must be woven together in standards, curriculum, instruction, and assessments. When students explore particular disciplinary ideas, they do so by engaging in practices while also making connections to the crosscutting concepts.

To support this vision for science education in the *Framework*, educators must strive to deeply understand the three dimensions within the performance expectations, or indicators, and how students' facility with the practices, concepts, and ideas may develop over time as they progress across grades. This deep understanding of what students should know and be able to do at each grade or grade span in science is a cornerstone of principled assessment design. The unpacking tool is essential in this regard; it provides a means for educators to closely examine each dimension of the performance expectation before designing an assessment task.

In Module 2.2, our intent is to help you more deeply understand and distinguish between the three dimensions of the Next Generation Science Standards. We will also present and explain the elements of the unpacking tool—the foundations, key aspects, and prior knowledge—so that you can recognize these elements and understand how they relate to what is being measured. And finally, we will walk you through a model unpacking tool and provide additional completed samples across grade bands so that you can understand the outcomes of the unpacking process.



The NGSS are for all students, and all students are expected to achieve proficiency with respect to all the performance expectations in the NGSS over their K–12 educational experience. The architecture of a performance expectation is intentional to support instruction and assessment of that instruction for all students.

Distinguished from prior science standards, the PEs state what students should be able to do in order to demonstrate that they have met the standard, thus providing the *same* clear and specific target for curriculum, instruction, and assessment. Each performance expectation incorporates all three dimensions from the *Framework*—a SEP, a DCI, and a CCC.

As shown in this illustration, each set of performance expectations has a title or identified specific core idea in one of the four disciplines, followed by a box containing the performance expectations related to that topic. Each PE combines the skills and ideas that students need to learn, while it suggests ways of assessing whether or not students have the capabilities and understandings specified in the three color-coded foundation boxes shown below the PE.

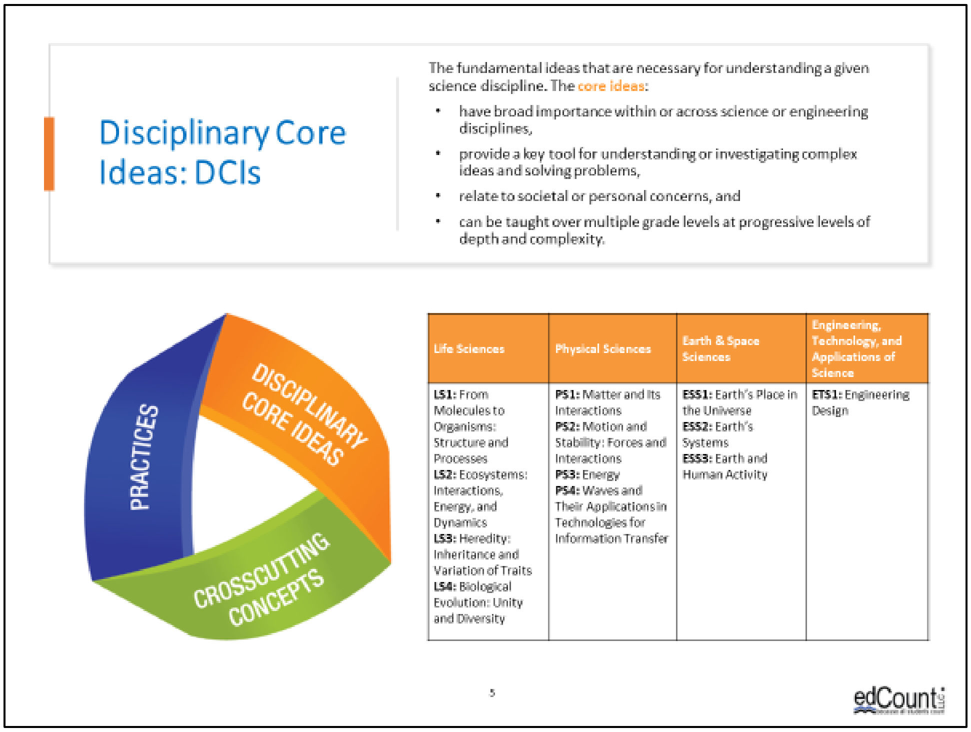
The three foundation boxes listed from left to right indicate the science and engineering practices (SEPs), disciplinary core ideas (DCIs), and crosscutting concepts (CCCs) combined to reflect the set of performance expectations stated here.

In instances when there are multiple PEs for a specific core idea in science, the code associated with the PE will be included with its associated statements in the foundation boxes. In this provided grade 5 example, note that there are three grade 5 PEs associated with Earth

Systems—5-ESS2-1, 5-ESS2-2, and 5-ESS3-1. The foundation boxes list unique statements that may be associated with one or more PE, which are denoted by the corresponding PE codes indicated in parentheses after the statement. For example, the CCC, *Systems and System Models* is associated with both 5-ESS2-1 and 5-ESS3-1, whereas *Scale, Proportion, and Quantity* is only associated with 5-ESS2-2.

Another unique feature of the NGSS are the connections to other ideas within the disciplines of science and engineering and with Common Core State Standards in mathematics and English language arts to promote coherence.

Please refer to additional resources in the Web Links pod, which include two videos related to "How to Read the NGSS" and "What is the NGSS?" In the Resources pod, you can find the PDF, "How to Read the NGSS."

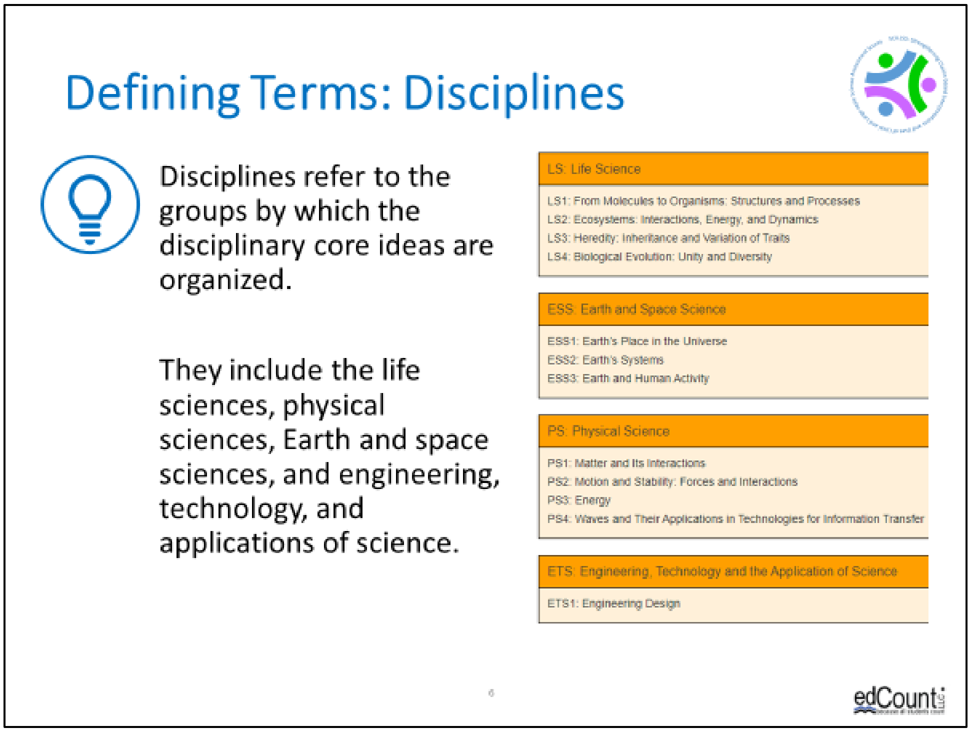


The *Framework* identifies a small number of disciplinary core ideas, or DCIs, that all students should learn with increasing depth and sophistication, from kindergarten through grade twelve. The DCIs identify important core ideas of science, which potentially create a focus for K–12 science curriculum, instruction, and assessments and create the conceptual toolkit that students use to reason about phenomena and/or design solutions.

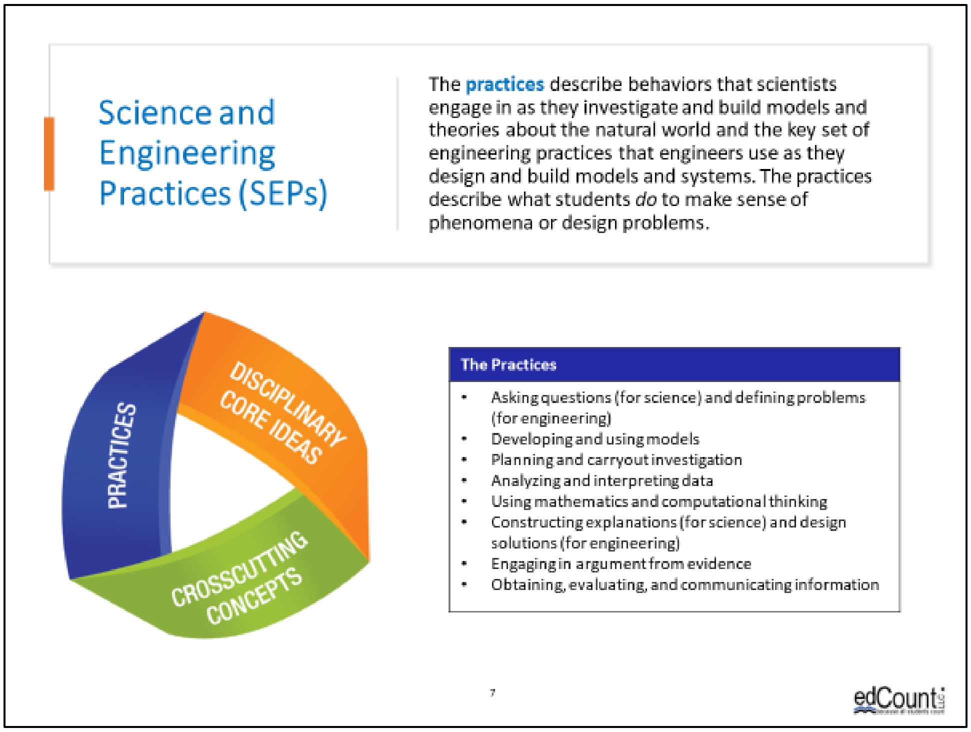
Specifically, a core idea for K–12 science instruction should:

1. Have broad importance across multiple sciences or engineering disciplines or be a key organizing principle of a single discipline;
2. Provide a key tool for understanding or investigating more complex ideas and solving problems;
3. Relate to the interests and life experiences of students or be connected to societal or personal concerns that require scientific or technological knowledge; and
4. Be teachable and learnable over multiple grades at increasing levels of depth and sophistication. That is, the idea can be made accessible to younger students but is broad enough to sustain continued investigation over multiple years.

The disciplinary ideas are organized into four major disciplines: Life Sciences, Physical Sciences, Earth and Space Sciences, and Engineering, Technology and Applications of Science. While these four disciplines are presented separately, it's important to acknowledge that multiple connections exist among disciplines. With increasing frequency, scientists work in interdisciplinary teams that blur traditional boundaries. As a consequence, in some instances, core ideas, or elements of core ideas, appear in several disciplines, such as, for example, energy and human impact on the planet (the *Framework*, NRC, 2012, p. 31).

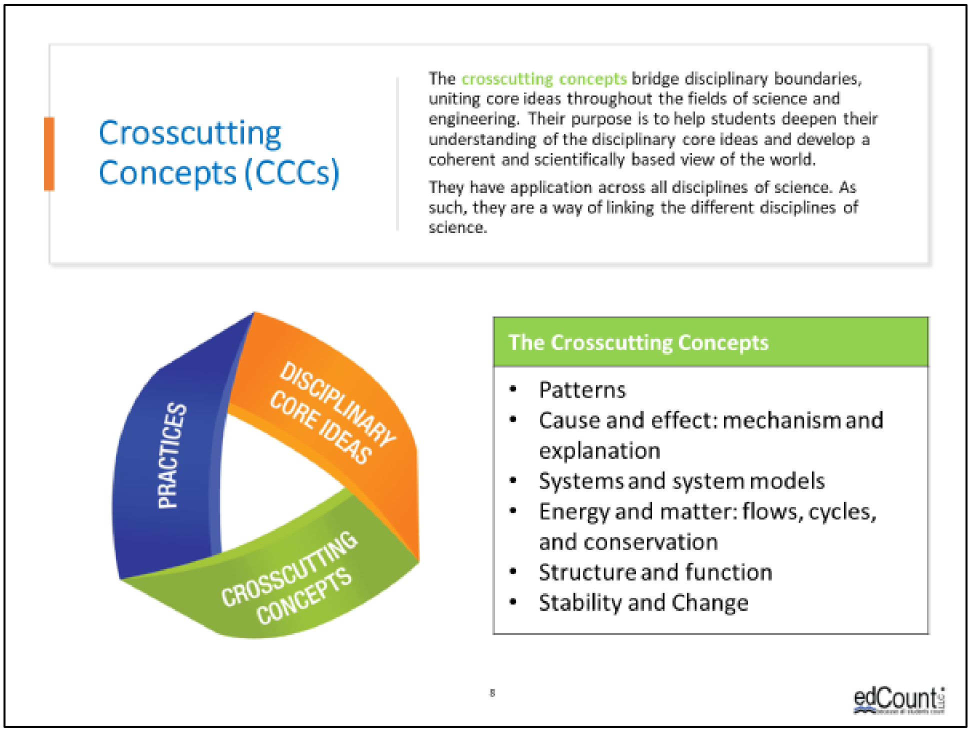


The term “Discipline” refers to the groups by which the DCIs are organized. They include Life Sciences, Physical Sciences, Earth and Space Sciences, and Engineering, Technology and Applications of Science.



Students learn the disciplinary core ideas in the context of science and engineering practices. The practices reflect the essence of how the scientific and engineering communities and students should work to generate knowledge. They are meant to shift how we traditionally view science curriculum and instruction to focus on what students are doing. Teaching and learning science can require students to engage with each and/or multiple practices at a time to build scientific knowledge.

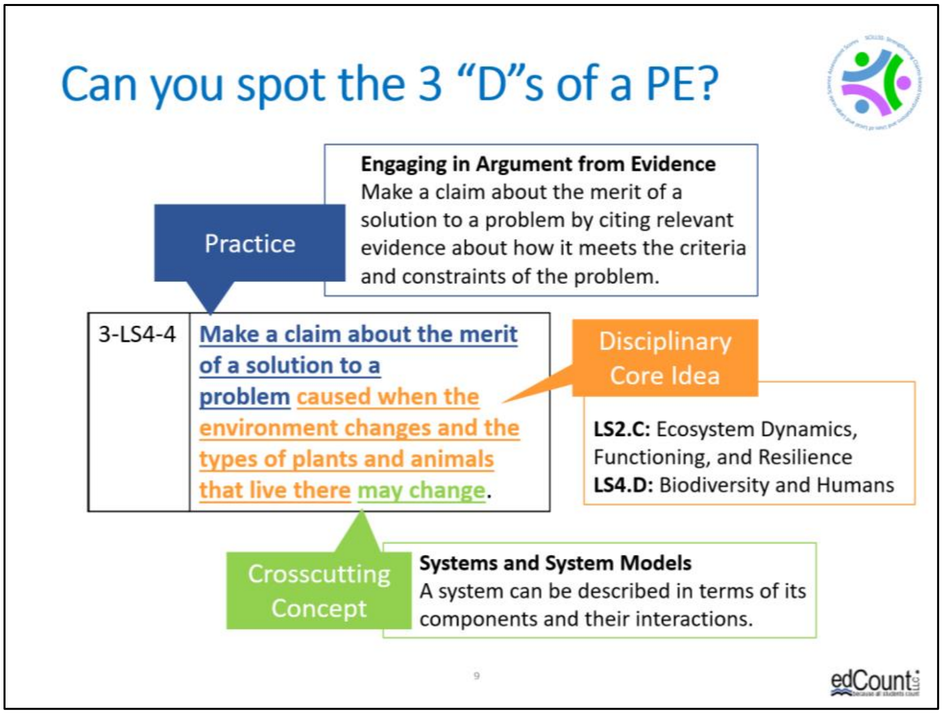
The focus here is on important practices, such as modeling, developing explanations, and engaging in critique and evaluation, or argumentation, that have too often been underemphasized in the context of science education (the *Framework*, NRC, 2012, p. 44). As students engage in the practices while learning disciplinary core ideas, they will develop an increasing facility and inclination to call on these practices, separately or in combination, as needed to support their learning, and to demonstrate their understanding of science and engineering (the *Framework*, NRC, 2012, p. 49).



The seven crosscutting concepts are unifying concepts or common themes in science that provide lenses for exploring and explaining phenomena. These concepts are considered "unifying" or "common" because they emerge in multiple disciplinary contexts and have explanatory value throughout much of science and engineering. According to the *Framework*, crosscutting concepts provide students with an organizational framework for connecting knowledge from the various disciplines into a coherent and scientifically-based view of the world (NRC, 2012, p. 83).

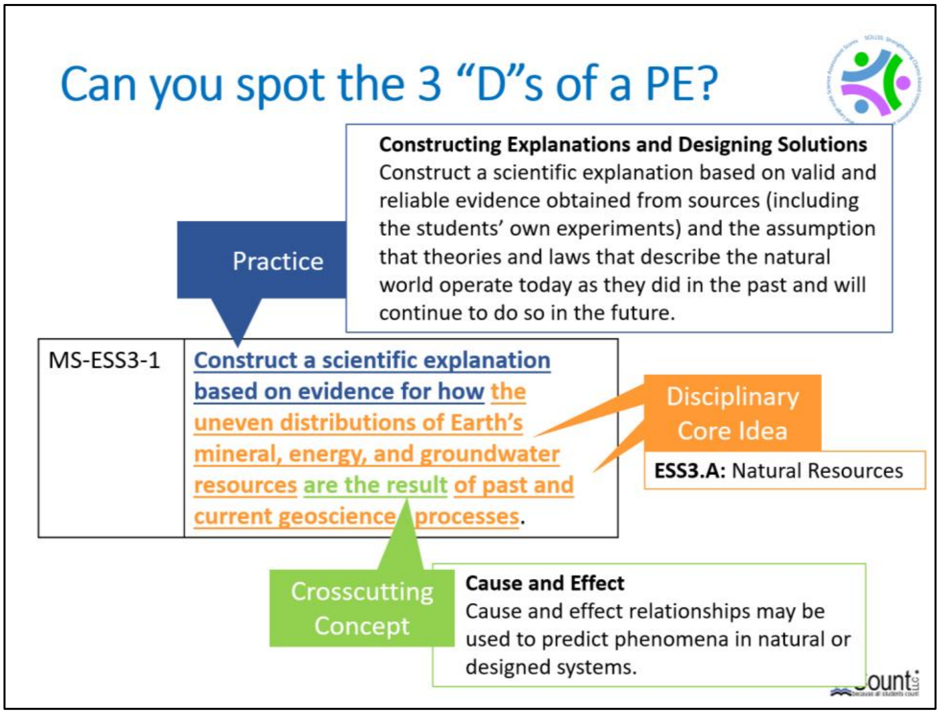
In the science classroom, crosscutting concepts have an important role in standards, curriculum, instruction, and assessment because they serve as common and familiar touchstones across the disciplines and grade levels. Let's take the crosscutting concept of patterns as an example. Observed patterns and questions about relationships and the factors that influence them are prevalent concepts across the four disciplines of Life Sciences, Physical Sciences, Earth and Space Sciences, and Engineering, Technology and Applications of Science. The concept of patterns is also a unifying theme for instruction across the elementary, middle, and high school grade spans. In elementary school, students might explore the concept of patterns as they describe and predict the patterns in the seasons of the year, or when they observe and record patterns in the similarities and differences between parents and their offspring. They might also investigate the characteristics that allow for the classification of animal types, plants, or materials. In middle school, these classifications become more detailed and sophisticated as students relate patterns to the nature of microscopic and atomic-level structures. By high school, students recognize that different patterns may be observed at each of the scales at which a system is studied.

Let’s carry on with an activity in which you will have an opportunity to identify or “spot” the three dimensions of an elementary, middle school, and high school PE.



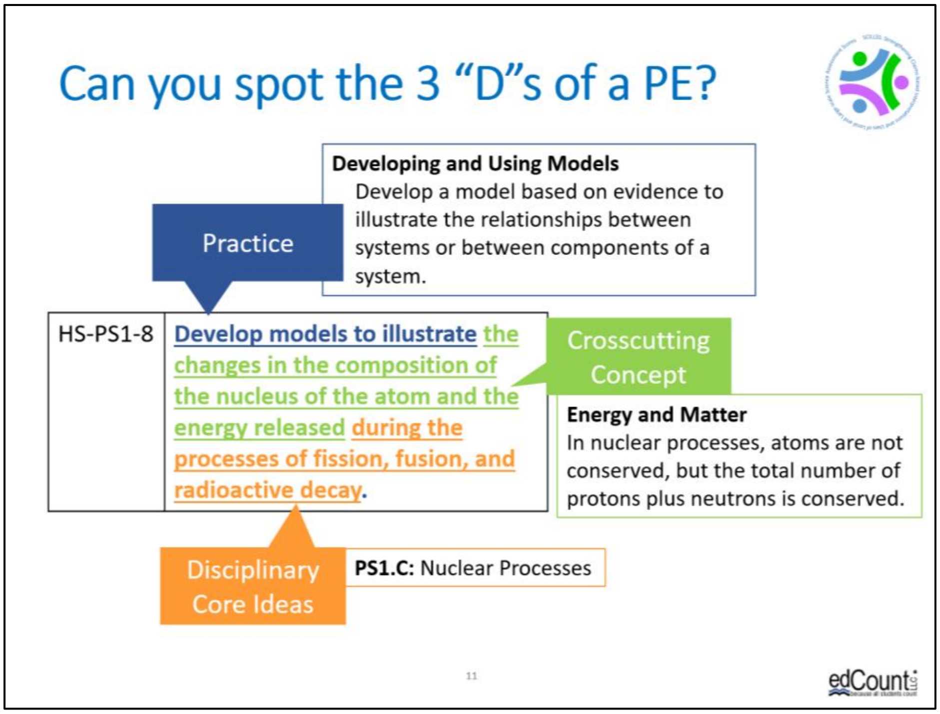
Performance expectations are the assessable statements of what students should know and be able to do. Let's closely examine a grade 3 Life Science PE: *3-LS4-4: Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change.*

Please pause the presentation and see if you can you spot the practice, disciplinary core idea, and crosscutting concept in this grade 3 performance expectation. Then resume the presentation to view the identification of each dimension.



Here is a middle school Earth and Space Science PE: *MS-ESS3-1: Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes.*

Please pause the presentation and see if you can you spot the practice, disciplinary core idea, and crosscutting concept in this middle school performance expectation. Then resume the presentation to view the identification of each dimension.

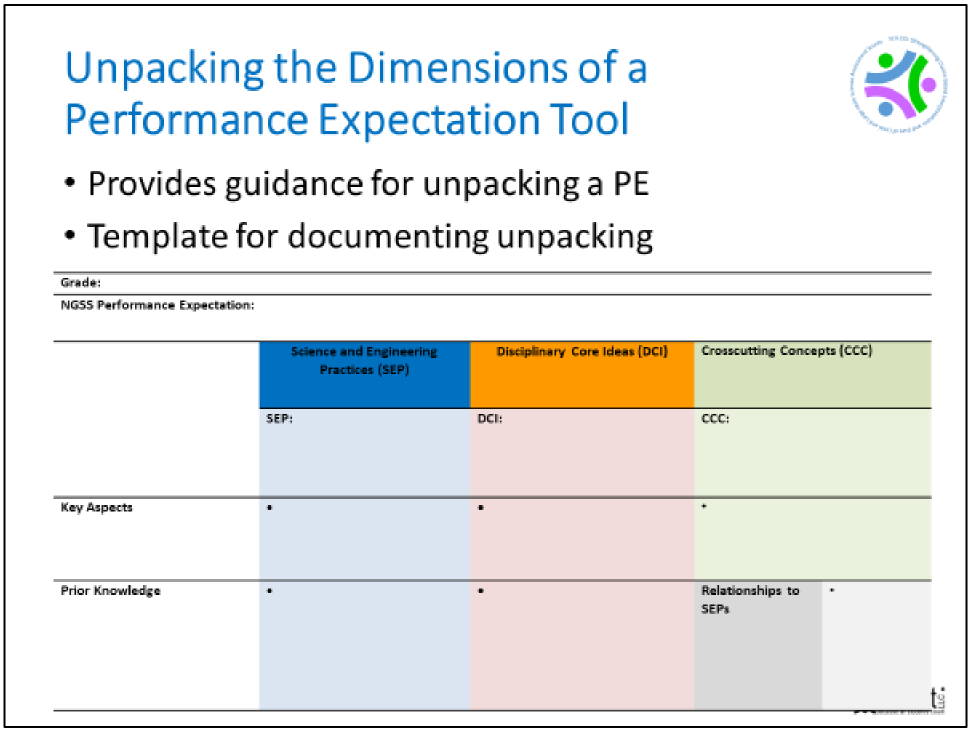


This is a high school Physical Science PE: *HS-PS1-8: Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.*

Please pause the presentation and see if you can you spot the practice, disciplinary core idea, and crosscutting concept in this high school performance expectation. Then resume the presentation to view the identification of each dimension.

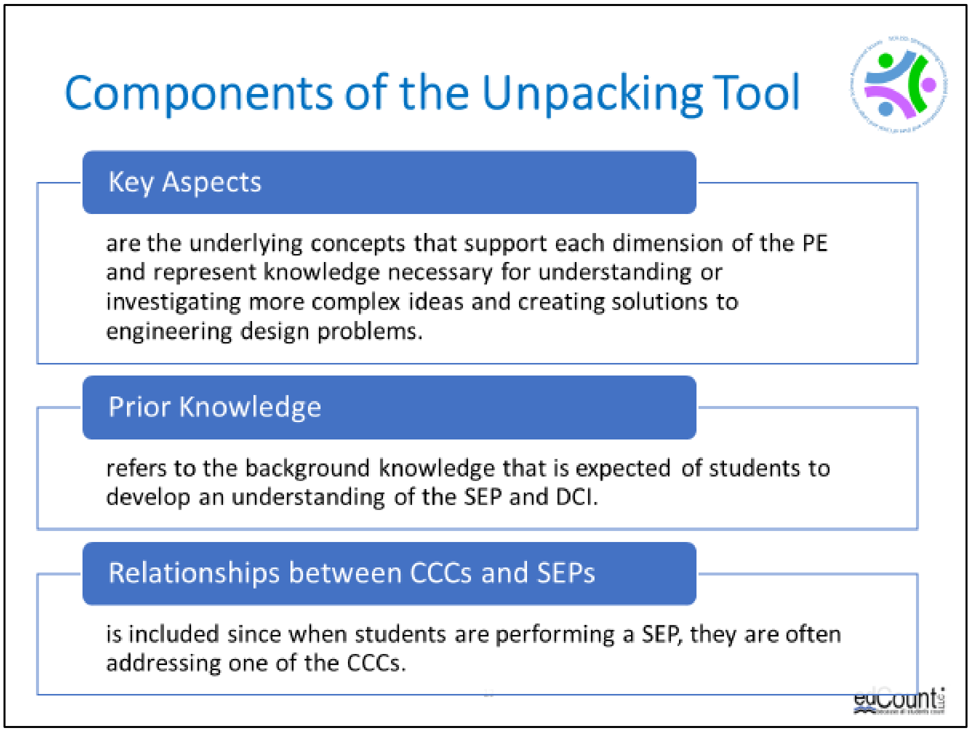
Having identified the three dimensions of a grade 3, middle school, and high school PE, next, we will introduce the unpacking tool template, the first of two design tools that lead to the intentional design of assessment tasks for a selected PE.

The unpacking tool—a design tool used to "unpack" and document the dimensions of a selected PE—leads to a better understanding and identification of its assessable components.



Unpacking the dimensions of each PE provides a clear focus for what is to be measured and helps educators to plan for assessment. The unpacking tool supports a systematic approach to unpacking a performance expectation into its multiple components to ensure educators who are designing NGSS-aligned tasks have a clear and deep understanding of each of the dimensions represented in a performance expectation and what constitutes evidence of student learning prior to task development.

Here we show the unpacking tool template. To complete the unpacking tool, you must unpack the SEP, the DCI, and the CCC associated with a PE by considering the key aspects and prior knowledge of each dimension. In the crosscutting concepts column, highlighted in green, the template also provides a place to document the relationships between the CCC and the SEP.

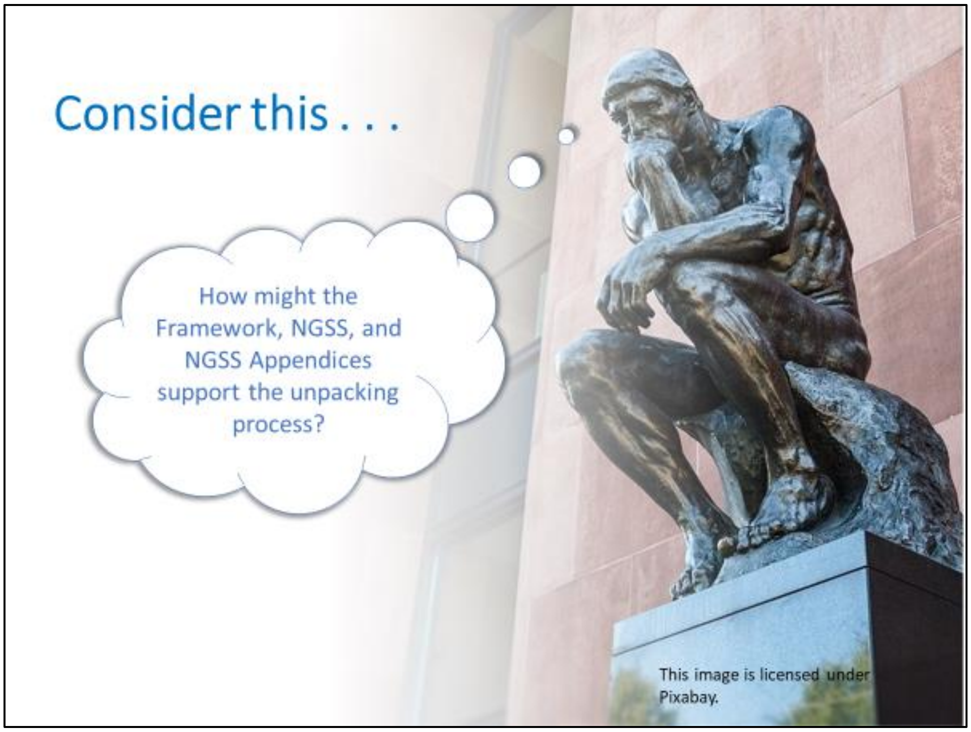


Let’s take a closer look at each element of the unpacking tool.

First, we identify the key aspects within each of the three dimensions that are present in the PE but are not entirely explicit. Key aspects are the underlying concepts that support each dimension of the PE and represent knowledge necessary for understanding or investigating more complex ideas and solving problems. Thinking about each dimension separately ensures that when the dimensions are brought back together, they are integrated into the assessment task. The reason for doing this is to ensure that the resulting task assesses students’ ability to apply their understanding of the dimensions to explain phenomena or create solutions to engineering design problems.

Next, we identify prior knowledge. Prior knowledge refers to the background knowledge that is expected of students to develop an understanding of the SEP and DCI. Prior knowledge includes the knowledge, skills, and abilities students are expected to have acquired from a previous grade or prior instruction.

Finally, we also consider the relationships between the CCC and the SEP. When students are performing a SEP, they are often addressing one of the CCCs. For example, the CCC *Scale, Proportion, and Quantity* is an essential consideration when deciding how to develop a model to describe a phenomenon.



We recommend a selection of resources to support the unpacking process, including the *Framework*, the NGSS, and NGSS Appendix E: Disciplinary Core Idea Progressions, Appendix F: Science and Engineering Practices, and Appendix G: Crosscutting Concepts. The NGSS appendices describe the progressions across grades K–12, summarizing the main focus of the science disciplinary content and the specific elements of each practice and CCC at each grade band, respectively. You can access each of these documents in the Web Links pod.

Please pause the presentation and consider how each of these resources might support the identification of key aspects, prior knowledge, and relationships between the CCC and SEP for a chosen PE. What information do these resources provide that are particularly relevant or helpful? These resources are described in greater detail in Module 2.4.

When you are ready to resume the presentation, we will engage in a guided walk-through of a completed grade 5 unpacking tool.

Unpacking Tool for 5-PS1-1

Grade: 5

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

	Science and Engineering Practices (SEP)	Disciplinary Core Ideas (DCI)	Crosscutting Concepts (CCC)
Foundations	**SEP: Developing and Using Models** Use models to describe phenomena.	**PS1.A: Structure and Properties of Matter** Matter of any type can be subdivided into particles that are too small to see, but even then, the matter still exists and can be detected by other means. A model showing that gases are made from matter particles that are too small to see and are moving freely around in space can explain many observations, including the inflation and shape of a balloon and the effects of air on larger particles or objects.	**CCC: Scale, Proportion, and Quantity** Natural objects exist from the very small to the immensely large.

In the next few slides, we walk through a completed unpacking tool for the grade 5 performance expectation, *5-PS1-1: Develop a model to describe that matter is made of particles too small to be seen.* At the end of this module, we provide additional examples of unpacking tools for the elementary, middle, and high school grade bands.

For this particular task, students are expected to develop a model to describe that matter is made up of particles too small to be seen. The NGSS PE is listed, which includes its clarification statement in red, and each of the dimensions associated with the PE are provided in the color-coded foundation boxes below the PE. All content in the first portion of the unpacking tool is taken directly from the NGSS.

Please take a moment to familiarize yourself with the performance expectation and its dimensions. What knowledge and skills are associated with each dimension of this PE? How are the three dimensions interconnected in the PE?

Please pause the presentation now. When you are ready to resume the presentation, we will take a closer look at the key aspects and prior knowledge associated with each dimension.

Unpacking Tool for 5-PS1-1

Grade: 5	
NGSS Performance Expectation: 5-PS1-1 Develop a model to describe that matter is made of particles too small to be seen. [Clarification Statement: Examples of evidence supporting a model could include adding air to expand a basketball, compressing air in a syringe, dissolving sugar in water, and evaporating salt water.] [*Assessment Boundary: Assessment does not include the atomic-scale mechanism of evaporation and condensation or defining the unseen particles.*]	
	Disciplinary Core Ideas (DCI)
Foundations	**PS1.A: Structure and Properties of Matter** Matter of any type can be subdivided into particles that are too small to see, but even then, the matter still exists and can be detected by other means. A model showing that gases are made from matter particles that are too small to see and are moving freely around in space can explain many observations, including the inflation and shape of a balloon and the effects of air on larger particles or objects.
Key Aspects	• Everything around us (matter) is made up of particles that are too small to be seen. • Matter that cannot be seen can be detected in other ways. • Gas (air) has mass and takes up space. • Gas (air) particles, which are too small to be seen, can affect larger particles and objects. • Gas particles freely move around in space until they hit a material that keeps them from moving further, thus trapping the gas (e.g., air inflating a basketball, an expanding balloon).
Prior Knowledge	• Matter is anything that occupies space and has mass. • Matter can change in different ways.

In this portion of the unpacking tool, we begin “teasing apart” the disciplinary core idea. Essentially, what you see is that the bullets unpack the DCI concepts from *PS1.A: Structure and Properties of Matter*.

Let’s begin by reading the description of PS1.A, as described in the NGSS: *Matter of any type can be subdivided into particles that are too small to see, but even then, the matter still exists and can be detected by other means. A model showing that gases are made from matter particles that are too small to see and are moving freely around in space can explain many observations, including the inflation and shape of a balloon and the effects of air on larger particles or objects.*

What are the key aspects of this disciplinary core idea? What underlying concepts, or knowledge, are necessary for students to understand or investigate more complex ideas and solve problems? For this DCI, we would expect students to understand that:

- *Everything around us (matter) is made up of particles that are too small to be seen;*
- *Matter that cannot be seen can be detected in other ways;*
- *Gas (air) has mass and takes up space;*
- *Gas (air) particles, which are too small to be seen, can affect larger particles and objects;* and

- *Gas particles freely move around in space until they hit a material that keeps them from moving further, thus trapping the gas (e.g., air inflating a basketball, an expanding balloon).*

Next, let's consider prior knowledge. Prior knowledge describes the DCI concepts students are expected to have from prior learning experiences. For this DCI, we would expect grade 5 students to understand that:

- *Matter is anything that occupies space and has mass;* and
- *Matter can change in different ways.*

Unpacking Tool for 5-PS1-1

Grade: 5

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

	Science and Engineering Practices (SEP)
Foundations	**SEP: Developing and Using Models** Use models to describe phenomena.
Key Aspects	• Identify components of the model. • Use a model to reason about a phenomenon. • Reason about the relationship of the different components of a model. • Select and identify relevant aspects of a situation or phenomena to include in the model.
Prior Knowledge	• Knowledge that a model contains elements (observable and unobservable) that represent specific aspects of real-world phenomena • Knowledge that models are used to help explain or predict phenomena

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In this portion of the unpacking tool, we begin "teasing apart" the science and engineering practice: *Developing and Using Models*. As we consider the key aspects of the practice, we must ask ourselves, what does it mean to "*use models to describe phenomena*"? For grade 5 students to use a model, they might need to:

- *identify components of the model;*
- *use a model to reason about a phenomenon;*
- *reason about the relationship of the different components of a model;* or
- *select and identify relevant aspects of a situation or phenomena to include in a model.*

The prior knowledge describes the background knowledge students are expected to have acquired from prior learning experiences to be able to, in this instance, understand how to develop a model. Grade 5 students should have:

- *knowledge that a model contains observable and unobservable elements that represent specific aspects of real-world phenomena*; and
- *knowledge that models are used to help explain or predict phenomena.*

Unpacking Tool for 5-PS1-1

Grade: 5	
NGSS Performance Expectation: 5-PS1-1 Develop a model to describe that matter is made of particles too small to be seen. [Clarification Statement: Examples of evidence supporting a model could include adding air to expand a basketball, compressing air in a syringe, dissolving sugar in water, and evaporating salt water.] [*Assessment Boundary: Assessment does not include the atomic-scale mechanism of evaporation and condensation or defining the unseen particles.*]	
	Crosscutting Concepts (CCC)
Foundations	**CCC: Scale, Proportion, and Quantity** Natural objects exist from the very small to the immensely large.
Key Aspects	• Understand the units used to measure and compare quantities. • Describe relationships between natural objects which vary in size (very small to the immensely large). • Understand that scale involves not only understanding systems and processes vary in size, time span, and energy, but also different mechanisms operate at different scales.
Relationships to SEPs	• Models describe the scale of natural objects. • Data analysis serves to demonstrate the relative magnitude of some properties or processes. • Calculate proportions correctly and measure accurately for valid results.

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Finally, in this last portion of the unpacking tool, we begin "teasing apart" the crosscutting concept: *Scale, Proportion, and Quantity*.

In terms of key aspects of this crosscutting concept, we would expect grade 5 students to:

- *understand the units used to measure and compare quantities;*
- *describe relationships between natural objects which vary in size (very small to the immensely large);* and
- *understand that scale involves not only understanding systems and processes vary in size, time span, and energy, but also different mechanisms operate at different scales.*

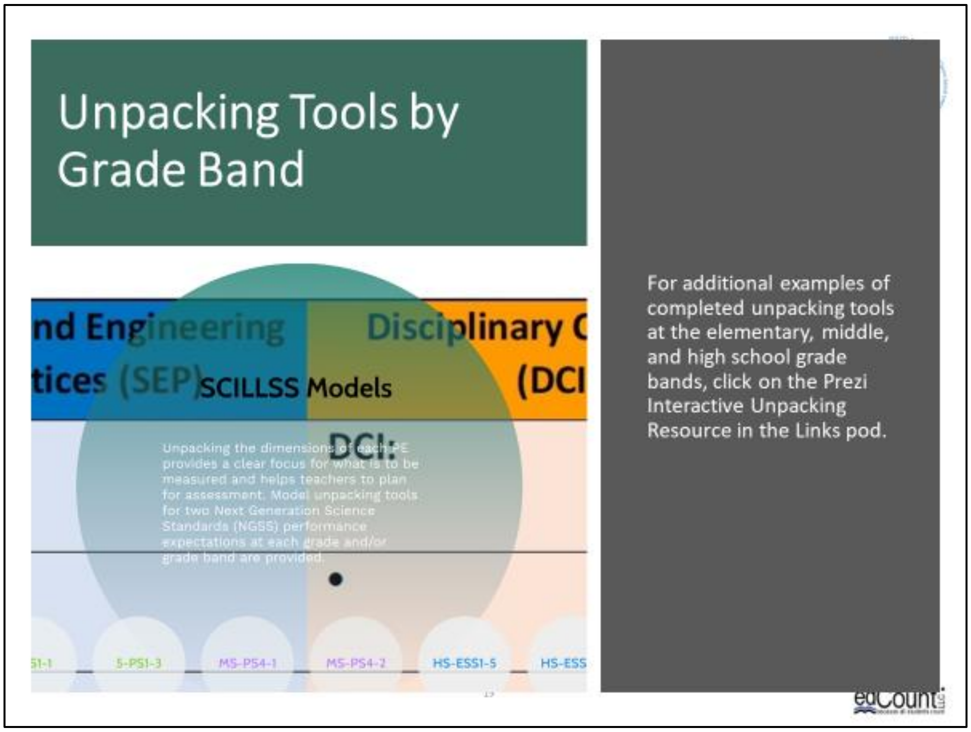
The relationships to SEPs describes the connection between the CCC and the practice. The CCC *Scale, Proportion, and Quantity* is an essential consideration when deciding how to develop a model to describe a phenomenon. To demonstrate their ability to use a model, students must understand that:

- *Models describe the scale of natural objects;* and
- *Data analysis serves to demonstrate the relative magnitude of some properties or processes.*

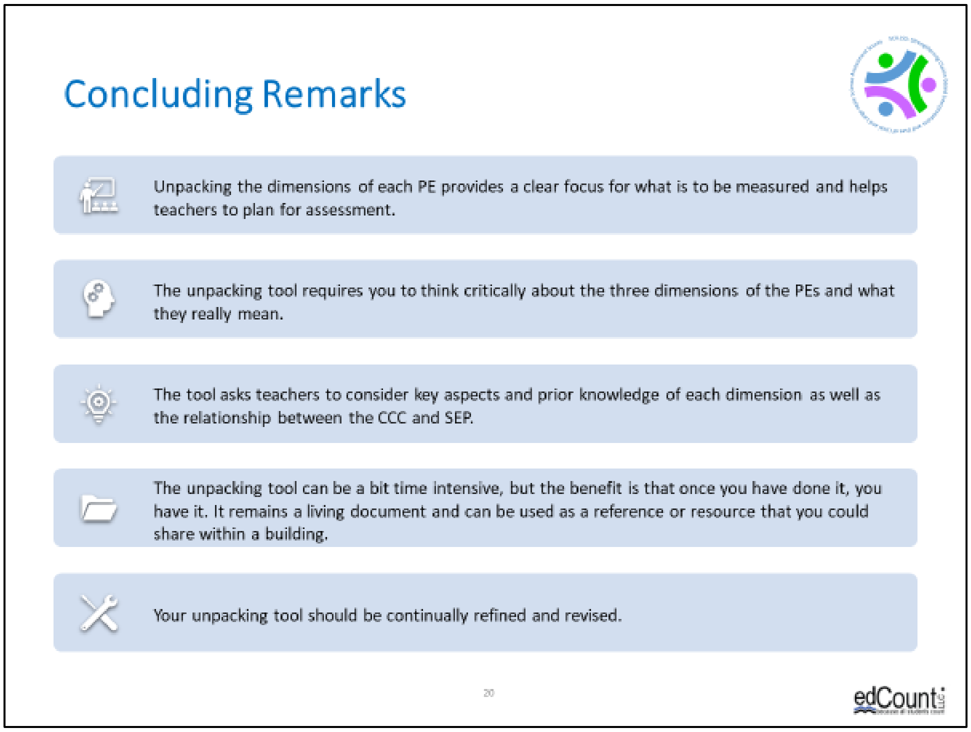
Students must also be able to:

- *calculate proportions correctly and measure accurately for valid results.*

Remember, as you complete the unpacking tool, you will rely in part on your own knowledge and expertise as an educator. However, you also have a range of resources at your disposal to help with this process, including the *Framework*, NGSS, and the NGSS appendices. We strongly recommend relying on these valuable resources in combination with your professional expertise as you engage in this work.



For additional examples of completed unpacking tools at the elementary, middle, and high school grade bands, click on the Prezi Interactive Unpacking Resource in the Web Links pod. These completed models are also available for download in the Resources pod.

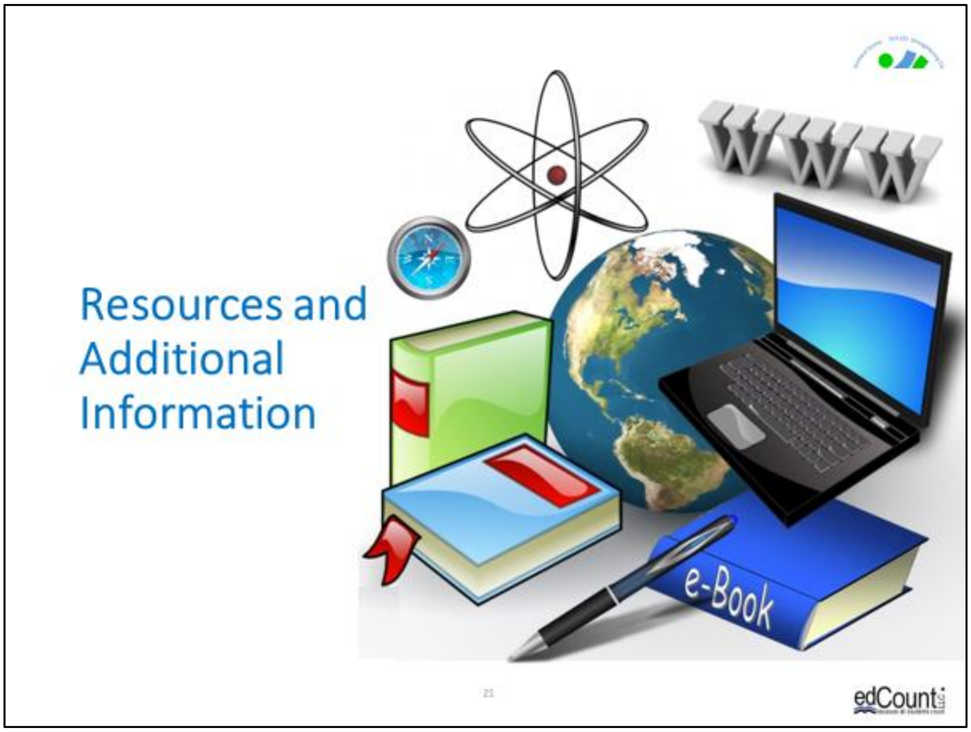


Creating an unpacking tool can be a bit time-intensive, but it has long-lasting benefits. It remains a living, foundational document that can be used within a classroom, building, or district to create a suite of assessment tasks aligned to a performance expectation.

Individual classroom educators or teams of educators collaborating in the design of common building or district assessments can revisit and refine the unpacking tool over time as they further reflect on and understand what students are expected to know and be able to do in science. Regardless of who uses the tool and for what purpose, it provides a means for educators to dive deep into the standards to clearly define the expectations and boundaries for student performance.

Take a moment to read and reflect on these concluding remarks. Think about how unpacking a performance expectation or indicator might help to improve your practice as an educator. How does thinking about the dimensions separately, and their interconnections, allow for a more complete understanding of what needs to be measured?

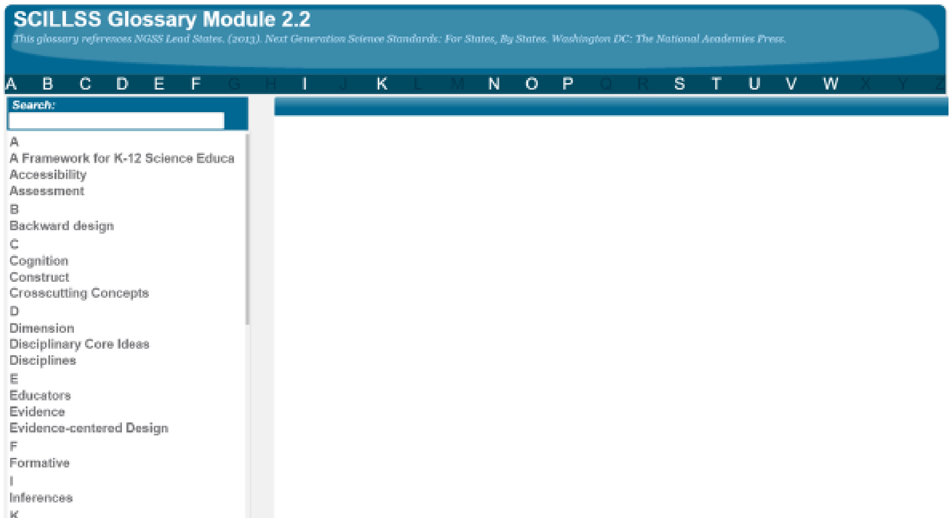
In the next module, Module 2.3, we offer a guided activity to engage more deeply in the elements of the unpacking tool. We will examine a series of statements from a completed unpacking tool and sort the statements into the appropriate dimension and element of the tool. This activity will provide practice differentiating between the three dimensions and the elements of the tool, including the key aspects, prior knowledge, and relationships between the CCC and SEP.



Finally, we offer additional resources that may be helpful to anyone interested in learning more about the concepts presented in this module. 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



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Resources

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

- How to Read the NGSS (video)
- What is the NGSS (Video)
- A Framework for K-12 Science Education
- Next Generation Science Standards
- Appendix E: Disciplinary Core Idea Progressions
- Appendix F: Science and Engineering Practices
- Appendix G: Crosscutting Concepts
- SCILLSS Model Unpacking Tools Prezi

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

- How to Read the NGSS (PDF)
- SCILLSS Model Unpacking Tools

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.

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