Example Bundles Guide

The Next Generation Science Standards (NGSS) identify what students should know and be able to do in science in order to be ready for college and careers. Because the NGSS are academic standards, they do not describe curriculum or the lessons and activities in which students engage during a course or year of instruction. Curriculum designed for the NGSS, including lesson plans, activities, scope and sequence documents, and assessments, is needed for classroom instruction.

The NGSS PEs are not intended to be taught or assessed one-at-a-time, or in isolation. Therefore, one helpful approach to beginning the translation of the NGSS into curriculum and instruction is to "bundle" standards together, arranging them in groups for instruction. Bundles of standards can be helpful to show connections between ideas, facilitate phenomenon-driven instruction, and promote efficient use of instructional time. They can form end goals for instruction at a similar scale to that of traditional curricular units. Several bundles can be assembled such that they coherently address all of the standards found within a grade level of instruction; when this process is done strategically, the bundles can form the outline of an entire course.

This Example Bundles Guide explains, in detail, considerations related to bundling. The Guide accompanies a set of concrete examples within each grade level K–12 of what it can look like when several related standards are bundled together. They are by no means the only way that standards could be bundled together, but they are designed to be illustrative of the process of bundling and the types of thinking necessary in building bundles that capitalize on the connections between standards. Curriculum developers can use these example bundles in thinking about how they will create and arrange bundles in a way that coherently builds student proficiency in all three dimensions of the standards.

This Guide is intended to enable a user to read and navigate the Example Bundles documents. Another focus is to explain how to use the principle of "bundling." These two ideas overlap a great deal. Users that are working to gain a deep understanding of bundling should review these documents following this sequence: First, ensure you are very familiar with the NGSS and the National Research Council's (NRC) *Framework for K–12 Science Education*, on which the NGSS were based. Then, read through this Guide and at least one Example Bundle course (a model for one instructional year) for an introduction to bundling.

Table of Contents

Key Definitions of This Guide

A number of terms have a technical significance in this Guide that goes beyond their typical use in the education community. Please review this section before moving on to other parts of the Guide.

Bundle - A bundle is a group of performance expectations that have been brought together to organize instruction. A bundle in this document is intended to match the scale of the instructional "unit," as it is commonly thought of in many education settings. Additionally, within the Example Bundles, a bundle document identifies an underlying rationale and assumptions about the relationships between the performance expectations that have been grouped together.

Bundling - The iterative process of developing a bundle of performance expectations for purposes of both instruction and assessment.

CCC - Crosscutting Concept. There are seven crosscutting concepts in the NGSS, described in the *Framework for K-12 Science Education*. The progression for each crosscutting concept across the grade bands is outlined in NGSS Appendix G, with the associated elements identified in the foundation box of each performance expectation.

Course - A course is a group of bundles that collectively address all of the performance expectations in a grade level.

Course set - A course set is a set of courses that collectively address all of the performance expectations in the middle school (6–8) or high school (9–12) grade bands.

DCI - Disciplinary Core Idea. The DCIs are defined by the *Framework for K-12 Science Education*, outlined in NGSS Appendix E, with the associated elements identified in the foundation box of each performance expectation.

ED - Engineering Design. This is the title of one of the Engineering, Technology, and Applications of Science Disciplinary Core Ideas from the *Framework for K-12 Science Education*.

ETS - Engineering, Technology, and Applications of Science. This is one of the four content categories of the Disciplinary Core Ideas in the NRC Framework and the NGSS.

Grade band - In the NRC *Framework* and the NGSS, a grade band is a set of grades for elementary grades (K–2 and 3–5), middle school (6–8) or high school (9–12). The middle and high school grade bands do not indicate a sequence within the band, but they do organize all of the performance expectations that should be addressed for that band. In the elementary grades, however, the NGSS describes which performance expectations are at each grade level.

NGSS Element - An NGSS element is a grade band-specific part of a Disciplinary Core Idea, Crosscutting Concept, or Science and Engineering Practices[1]. NGSS elements are often formatted with bullets and are identified by the title of a DCI, SEP, CCC, in the foundation box of a performance expectation.

NOS - Nature of Science Statement. There are eight categories of understandings about the nature of science that are outlined in NGSS Appendix H, and identified in the foundation boxes of select performance expectations. Four of the eight categories are integrated within Science and Engineering Practices and four are associated within Crosscutting Concepts.

[1] Anyone unfamiliar with the components of the NGSS is encouraged to review "How to Read the Standards" resources and videos on www.nextgenscience.org, and to become deeply familiar with the NGSS and the NRC Framework before using the Example Bundle documents.

NRC ***Framework*** - *A Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (NRC, 2012)

PE - Performance Expectations. These are the form in which the NGSS is written – as student performance expectations.

Phenomenon - Something observable that happens in the real world, whether natural or man-made. Student inquiry about phenomena—together with student-driven designing of solutions to problems—should drive instruction.

SEP - Science and Engineering Practice. There are eight practices, described by the *Framework for K-12 Science Education*. The progression for each SEP across the grade bands is outlined in NGSS Appendix F, with the associated elements identified in the foundation box of each performance expectation.

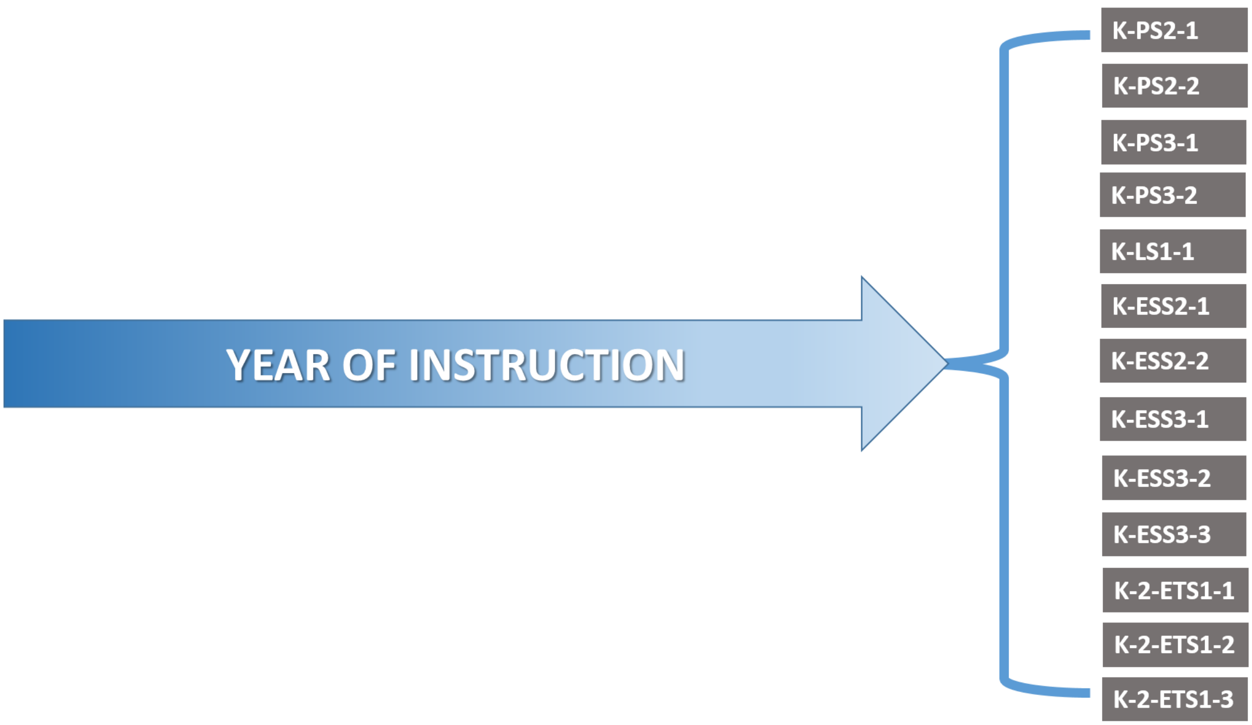
Back to the Table of Contents

Why is Bundling Important?

The Need

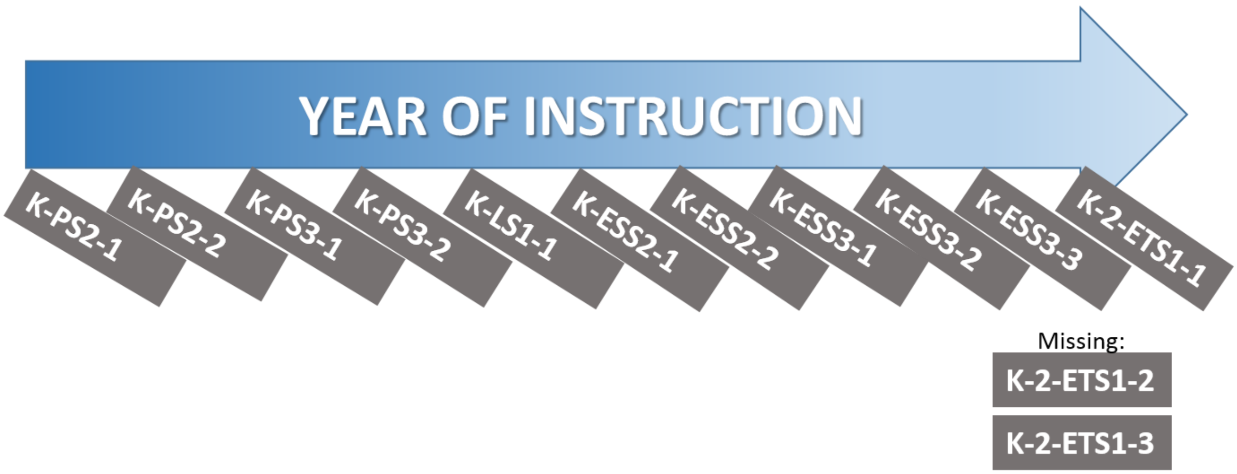
As states, districts, and educators implement the Next Generation Science Standards (NGSS), a critical step in their effort is translating the grade level (or grade band) endpoint standards into units of instruction that build all three dimensions of the NGSS over the course of a year or over multiple years. In the NGSS, the standards are often called performance expectations (PEs), and instruction can be organized in many different ways throughout a year to help prepare students to meet or exceed these expectations *by the end of the year*. Figures 1, 2, and 3 below represent what this could mean for the Kindergarten PEs of the NGSS.

Figure 1: *The NGSS Kindergarten PEs are all written as expectations of what students should be ready to perform* by the end *of their Kindergarten experience.*



The year or years of instruction leading to PEs is typically organized into units and lessons. One way to begin to organize instruction might be to target the PEs individually, sequencing them one at a time. However, this approach often leads to instruction taught without a cohesive storyline, and leads teachers and students to rush through content and entirely miss instruction on PEs sequenced toward the end of the year.

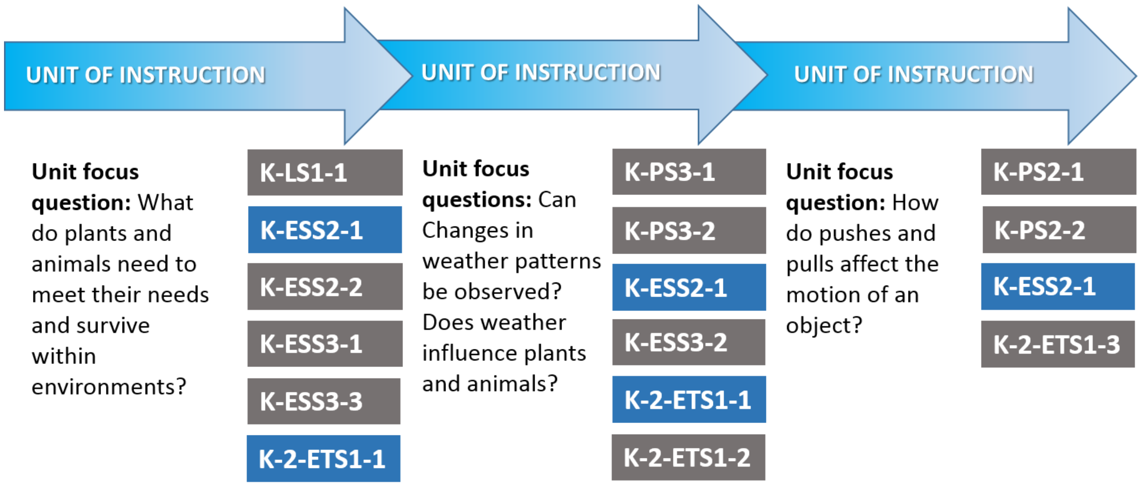
Figure 2: *What a Kindergarten lesson sequence might look like if instruction is organized for one PE at a time.*



The NGSS PEs are not intended to be taught or assessed one-at-a-time, or in isolation. Therefore, bundling PEs can be a useful step in organizing instruction. Curriculum developers can group PEs together in manageable arrangements to help students and teachers look for the connections between ideas that naturally exist in the sciences. Instruction that builds toward a bundle of related PEs simultaneously will also help students develop a more complete explanation of phenomena. Once these arrangements—or bundles—are developed, they may be used as the unit endpoints from which to design instruction and classroom assessment[2].

[2] Classroom assessment involves both summative and formative assessment. However the Example Bundles provide information about the end goals of instruction as opposed to interim steps. Comments on the development of formative classroom assessment and other aspects of assessment, including the design of implementation of assessment systems, are topics that exist outside of the scope of these documents.

Figure 3: *What a Kindergarten unit sequence might look like with a series of PE bundles over the course of a year. PEs in blue represent PEs that are only partially met in a particular unit.*



The Example Bundles were written to demonstrate some of the many ways PEs can be grouped together to support the development of a cohesive instructional unit. Additional examples of NGSS bundles are already available in the arrangements of the NGSS; the PEs were published in two different types of arrangements: by topic and by Disciplinary Core Idea (DCI). There is no one right way to bundle PEs, so the Example Bundles are just that—examples. Curriculum developers and others designing instructional units can be creative in their approach. The inclusion of multiple instructional-year models for each grade level in K–5 and each grade band in the secondary levels emphasizes the diverse possibilities available to teachers.

The Example Bundles also do not emphasize or include all of the aspects of developing three-dimensional instruction and curriculum. After standards are bundled, additional work must be done to develop lessons, activities, and assessments. Other resources are available that address important aspects of curriculum development and should be consulted before developing curriculum.[3]

Back to the Table of Contents

Who Can Use the Example Bundles?

The Example Bundles were created for curriculum designers and educators who develop curriculum, who have prior knowledge of the NGSS and the NRC *Framework*, and who are looking for a resource that will help them in the development of curricula for any grade level. A Suggestions for Use of the Example Bundles section is provided later in this Guide.

[3] See Appendix 2: Further Reading on Three-Dimensional Instruction

Getting Around the Documents

The Example Bundles documents are organized by courses, which are groups of bundles that collectively address all of the PEs in a grade level[4]. Each Example Bundle Course contains:

1. A Course Summary – a document that introduces a user to the themes of the year-long course, and briefly describes the way those themes are derived from the arrangement of the PEs within the bundles of the course.
2. A Course Flow Chart – a visual example of how the writers connected DCIs across bundles in a course.
3. Several Bundle Documents (one for each bundle of PEs) – each document includes a narrative about the connections between bundle PEs, example phenomena for the bundle, and additional science and engineering practices (SEPs), crosscutting concepts (CCCs), and nature of science (NOS) components that can be used in instruction toward the bundle.

Course Summary

Course Summaries begin with a narrative and rationale that explains the content overview for the year, the rationale for how the PEs were bundled throughout the year, and, for middle and high school courses, the source[4] of the year end-points for middle and high school.

The second part of the Course Summary includes one column for each bundle, indicating the number of example bundles in the course, the PEs grouped within those bundles, and a rough estimate of instructional duration (in weeks) for each bundle.

[4] In grades K–5, the NGSS were written as grade-level PEs, so the Example Bundles writers started with the PEs as the year endpoints. In grades 6–12, the NGSS were written as grade-banded PEs, so the Example Bundles writers started with various arrangements of the middle and high school PEs listed in or modified from NGSS Appendix K. For example, some of the middle school Example Bundles used the California Conceptual Progressions Course Map (page 20–21 of NGSS Appendix K) as the guide for grade level endpoints, because it was the first state-specific course map to be developed. Each Course Summary document describes the origin of its end-of-year endpoints.

Figure 4: *A Course Summary for Kindergarten*

Kindergarten Topic Model

Narrative and Rationale: The three bundles in this Kindergarten model are characterized by the overarching ideas that weather, sunlight, and the needs of living things affect us daily—ideas that apply to the physical, life, and Earth and space sciences, as well as engineering.

Bundle 1 centers on a guiding question about pushes and pulls on objects and their effects. Bundle 2 centers on a guiding question about the needs of plants and animals for food, water, and sunlight to survive. Bundle 3 centers on a guiding question about patterns and the effects of sunlight. While this framework is arranged by topic, the study of weather occurs throughout the year, over time.

In Kindergarten, students begin to build their understanding of the Crosscutting Concepts (CCCs) of patterns and the relationship between cause and effect in a logical progression over time. This model also introduces students to the Science and Engineering Practices (SEPs). It places special emphasis on planning and carrying out investigations, analyzing and interpreting data, engaging in argument from evidence, and constructing explanations and designing solutions. However, additional SEPs should be used throughout instruction. The SEPs contribute to students' understanding of both the CCCs and the Disciplinary Core Ideas (DCIs) they explore in Kindergarten. Students become familiar with SEPs over the course of the year, and the level of sophistication at which they are able to engage in the SEPs increases over time.

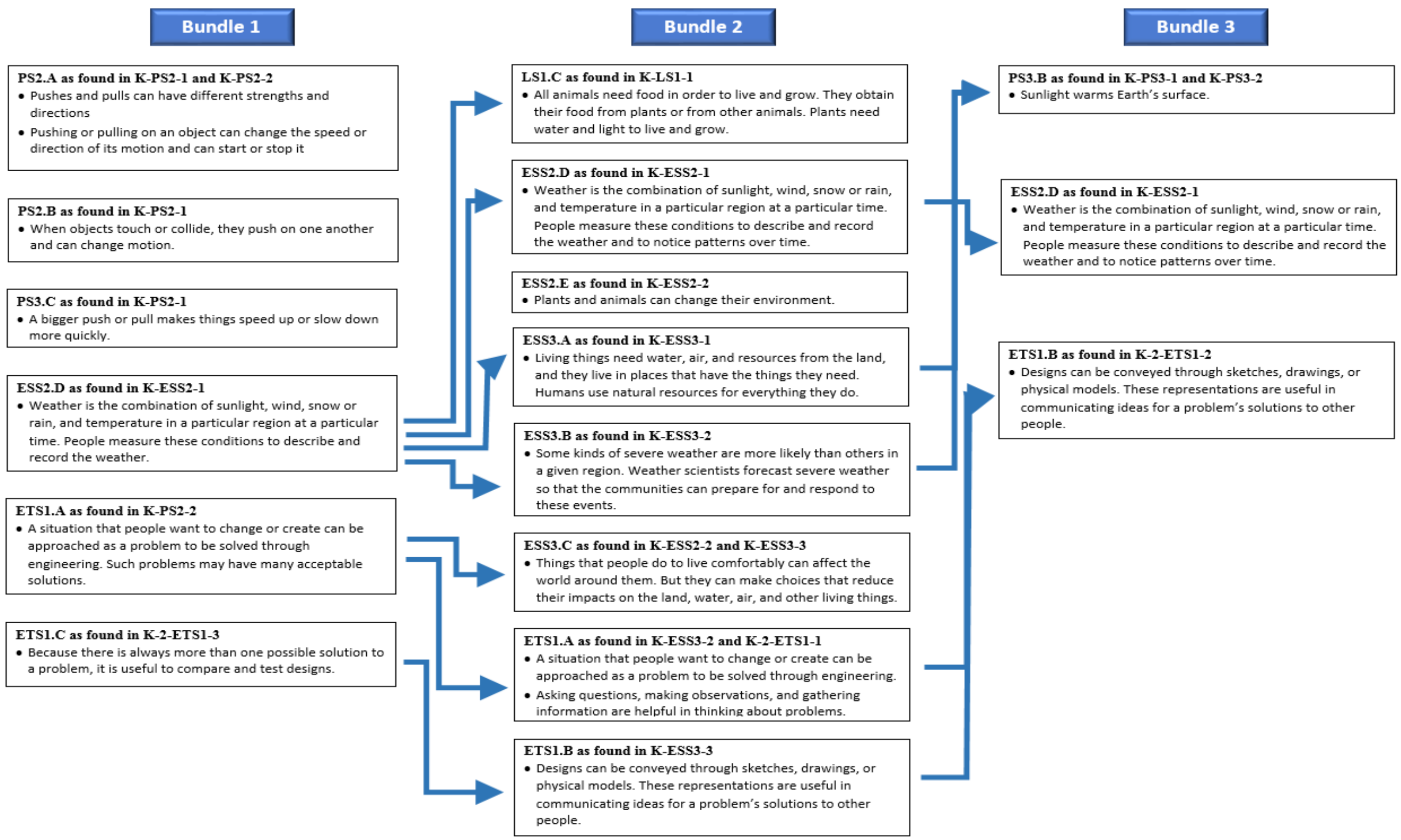
Bundle 1: How do objects move and what happens when they interact? **~4 weeks**	**Bundle 2:** What is the relationship between the needs of different plants and animals and the places they live? **~18 weeks**	**Bundle 3:** What can we observe about sunlight? **~14 weeks**
K-PS2-1. Plan and conduct an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object. **K-PS2-2**. Analyze data to determine if a design solution works as intended to change the speed or direction of an object with a push or a pull.* **K-ESS2-1**. Use and share observations of local weather conditions to describe patterns over time. [1] **K-2-ETS1-3.** Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.	**K-LS1-1**. Use observations to describe patterns of what plants and animals (including humans) need to survive. **K-ESS2-1.** Use and share observations of local weather conditions to describe patterns over time. [1] **K-ESS2-2.** Construct an argument supported by evidence for how plants and animals (including humans) can change the environment to meet their needs. **K-ESS3-1.** Use a model to represent the relationship between the needs of different plants and animals (including humans) and the places they live. **K-ESS3-2.** Ask questions to obtain information about the purpose of weather forecasting to prepare for, and respond to severe weather. **K-ESS3-3**. Communicate solutions that will reduce the impact of humans on the land, water, air, and/or other living things in the local environment.* **K-2-ETS1-1**. Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.[1]	**K-PS3-1.** Make observations to determine the effect of sunlight on Earth's surface. **K-PS3-2**. Use tools and materials provided to design and build a structure that will reduce the warming effect of sunlight on Earth's surface.* **K-ESS2-1**. Use and share observations of local weather conditions to describe patterns over time. **K-2-ETS1-2.** Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.

1. The bundle only includes part of this PE; the PE is not fully assessable in a unit of instruction leading to this bundle.

Course Flowchart

The Course Flow Chart shows the DCIs in each bundle of the course, indicates connections *between* the bundles, and provides a one-page overview of the progression of DCIs over the year. When the writers created and ordered the bundles throughout each year, these conceptual progressions were one of their main areas of focus. Therefore DCIs are emphasized in the flowchart because they were the dimension primarily used for the bundling and ordering process. However, SEPs and CCCs are also essential learning goals and components of instruction throughout the year, and are discussed in each bundle document. The DCI connections shown via the arrows in the flowchart are also not exhaustive; many more connections could be made. The arrows show opportunities for conceptual flow—not a sequence of instruction.

Figure 5: *An example of a Course Flowchart for Kindergarten*



Bundle Document

To demonstrate the rationale behind each PE bundle, each individual bundle document identifies some of the DCI-level connections within the bundle. Also, the Example Bundles make suggestions for using SEPs, CCCs, and NOS elements during instruction. These inclusions show how multiple SEPs and CCCs can be interwoven with DCIs while building students' understandings toward the PEs.

Each Example Bundle Document contains the following components[5]:

Summary - A narrative describing the connections between the DCIs, SEPs, and CCCs in the bundle.

Performance Expectation Chart - A list of each PE in the bundle.

Phenomena – Example engaging phenomena that could be used in instruction.

Additional Practices Building to the PEs – Suggestions for additional SEPs that could be used in instruction toward the bundle PEs. .

Additional Crosscutting Concepts Building to the PEs – Suggestion for additional CCCs that could be used in instruction toward the bundle PEs.

Additional Connections to Nature of Science (NOS) – Suggestion for additional NOS elements that could be used in instruction toward the bundle PEs.

Evidence Statements - Evidence Statements support summative assessment of a given PE or part of a PE, but can be used to inform instruction and formative assessment.

Back to the Table of Contents

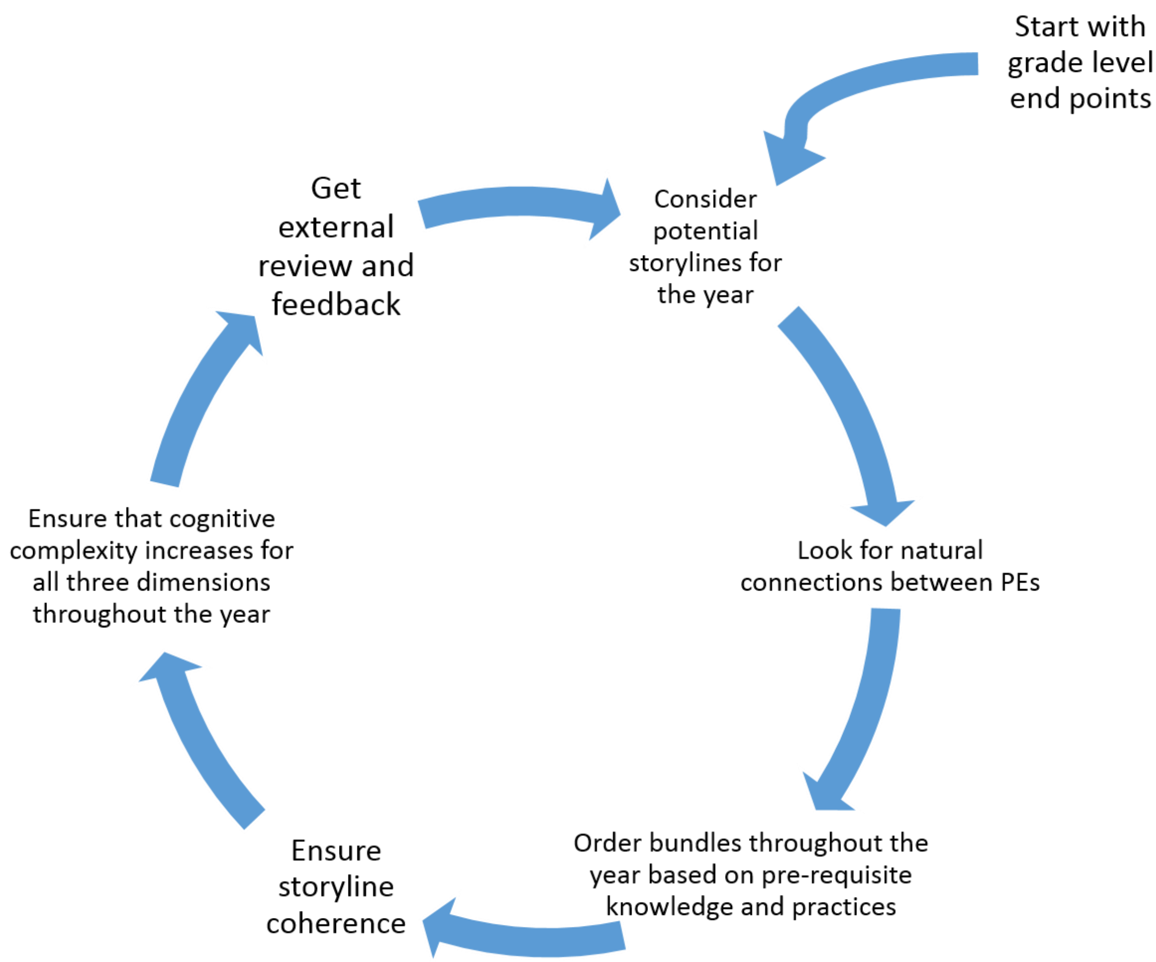
[5] A full explanation of the styles used in the Example Bundle Documents may found in Appendix 1: Example Bundle Styles and Explanations

Creating Bundles, Courses, and Course Sets

The Iterative Process of Creating the Example Bundles

In a process facilitated by Achieve, the Example Bundles were developed by teams of experts, including many of the NGSS writers and other educators and scientists[6], to demonstrate the design principles curriculum developers need to understand. For this reason, the idea of presenting multiple examples of course models and bundles was made a key feature of the Example Bundles from the outset.

Figure 6: *A summary of the iterative Example Bundles development process*



As described in the figure above, the Example Bundles were developed in an iterative process, where the writers began by looking at all the PEs in a grade level[4] and considering potential storylines that could help students build toward proficiency on those PEs by the end of the year. They then considered any natural connections between concepts of the different PEs in order to create potential bundles. The [Evidence Statements](#) for each PE were often used to help find natural connections between different

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[6] A full list of the Example Bundle writers who contributed to this project may be found in the Acknowledgements section.

PEs. For example, Figure 7 on the next page shows some possible connections between MS-LS1-7 and MS-PS1-5.

Figure 7: *The evidence statements for MS-LS1-7 and MS-PS1-5 are highlighted in purple to show potential connections.*

Evidence Statements for **MS-LS1-7**:

Observable features of the student performance by the end of the course:			
1	Components of the model		
	a	To make sense of a phenomenon, students develop a model in which they identify the relevant components for describing how food molecules are rearranged as matter moves through an organism, including:	
		i.	Molecules of food, which are complex carbon-containing molecules.
		ii.	Oxygen.
		iii.	Energy that is released or absorbed during chemical reactions between food and oxygen.
		iv.	New types of molecules produced through chemical reactions involving food.
2	Relationships		
	a	In the model, students identify and describe the relationships between components, including:	
		i.	During cellular respiration, molecules of food undergo chemical reactions with oxygen, releasing stored energy.
		ii.	The atoms in food are rearranged through chemical reactions to form new molecules.
3	Connections		
	a	Students use the model to describe:	
		i.	The number of each type of atom being the same before and after chemical reactions, indicating that the matter ingested as food is conserved as it moves through an organism to support growth.
		ii.	That all matter (atoms) used by the organism for growth comes from the products of the chemical reactions involving the matter taken in by the organism.
		iii.	Food molecules taken in by the organism are broken down and can then be rearranged to become the molecules that comprise the organism (e.g., the proteins and other molecules in a hamburger can be broken down and used to make a variety of tissues in humans).
		iv.	As food molecules are rearranged, energy is released and can be used to support other processes within the organism.

Evidence Statements for **MS-PS1-5**:

Observable features of the student performance by the end of the course:			
1	Components of the model		
	a	To make sense of a given phenomenon, students develop a model in which they identify the relevant components for a given chemical reaction, including:	
		i.	The types and number of molecules that make up the reactants.
		ii.	The types and number of molecules that make up the products.
2	Relationships		
	a	In the model, students describe relationships between the components, including:	
		i.	Each molecule in each of the reactants is made up of the same type(s) and number of atoms.
		ii.	When a chemical reaction occurs, the atoms that make up the molecules of reactants rearrange and form new molecules (i.e., products).
		iii.	The number and types of atoms that make up the products are equal to the number and types of atoms that make up the reactants.
		iv.	Each type of atom has a specific mass, which is the same for all atoms of that type.
3	Connections		
	a	Students use the model to describe that the atoms that make up the reactants rearrange and come together in different arrangements to form the products of a reaction.	
	b	Students use the model to provide a causal account that mass is conserved during chemical reactions because the number and types of atoms that are in the reactants equal the number and types of atoms that are in the products, and all atoms of the same type have the same mass regardless of the molecule in which they are found.	

Because they were developing multiple models, the writers considered different approaches[7] to connecting PEs, including looking at CCC themes and answering a driving question. Overall, the writers discovered that *bundles that were based on helping students make sense of a particular phenomenon worked the best in the models,* and this is an approach they would recommend for future bundles.

The writers then developed a sequence for the bundles within the instructional year by taking into account prerequisite concepts, storyline coherence, and cognitive complexity of each of the three dimensions. They focused on avoiding the "black box"—when students are asked to memorize content during one instructional unit but only begin to understand it in a later instructional unit. The writers then sought external feedback for the bundles and prototype courses in relation to the shifts of the NGSS and the vision of the NRC *Framework*. After revising the bundles in response to the feedback, the bundles were again externally reviewed and that feedback was incorporated. As schools and districts develop their own bundles, courses, and course sets, a similar iterative process should be employed.

[7] The approach taken to bundle PEs in a specific course model is described in the course summary and is used in the name of the course model (e.g., Kindergarten Thematic Model).

Creating Your Own Bundles

There are many important considerations for anyone working to create NGSS bundles, courses, and course sets. The assumptions and rationale that guide the formation of a bundle require careful consideration of the needs and characteristics of students in the classroom. The same reflective and collaborative thought process is required for organizing instruction and designing curriculum at every scale, from bundles, to courses, to course sets. Once curriculum developers have created bundles, they can begin to design lesson plans that collectively build toward the bundle—i.e., the instructional unit goals.

The following section outlines some questions to consider when you begin developing your own bundles. These considerations may be encountered in a variety of ways, and at different times in the development process, so they are identified without a specific sequence.

Considerations for Creating Your Own Bundles:

Scale

What is the scale of the curriculum that is being developed—is it a lesson, unit, year, or set of courses across multiple years? Is an individual bundle being created? Are a set of bundles being designed or redesigned to fit within other established curriculum?

Coherence

How are the SEPs, CCCs, and DCIs developed across each grade level and grade band? What do possible storylines suggest about the ways the PEs might be bundled and about the way bundles should be sequenced?

Phenomena

What phenomena might drive engaging lines of inquiry for the students served by this instruction? Will instruction focus on helping students explain a single phenomenon, or will different parts of instruction need to address different phenomena?

Connections

In what ways can CCCs and DCIs be used to explicitly make connections across bundles and between scientific disciplines? Are there other relevant connections between concepts? What about interdisciplinary connections to mathematics or English/language arts (ELA)? At what point in the school year will students be learning the associated mathematics and ELA concepts?

Implementation

What resources are available to support instruction? In what stage is the school or district in its transition to full NGSS implementation? Are the students ready for these DCIs, CCCs, and SEPs?

[Back to the Table of Contents]

Suggestions for Use of the Example Bundles

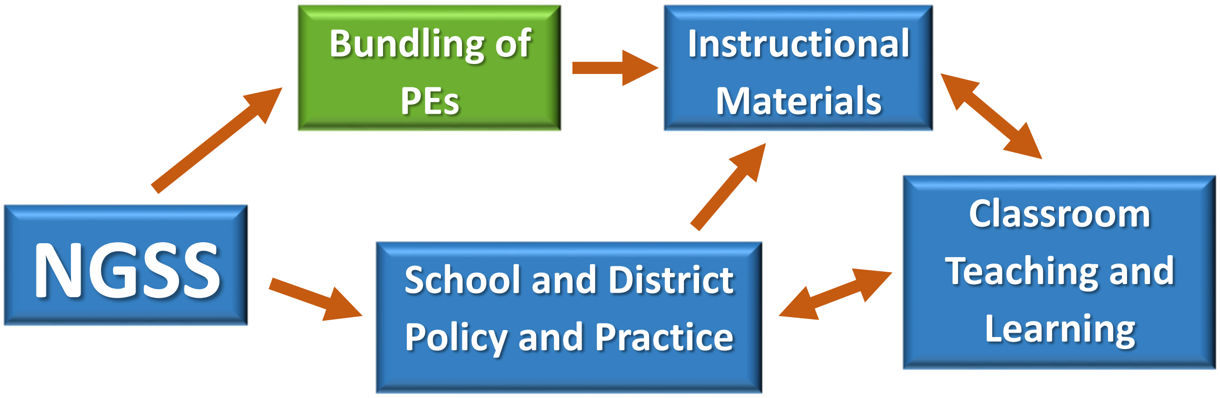

Figure 8: *Bundling is shown as an intermediary step in the instructional materials development process between the NGSS and the use of aligned instructional materials during instruction. Classroom teachers and school and district administrations are also shown as having large influences on the instructional materials that are used. This diagram does not show all the components and relationships in an education system.*

Teachers and School-based Curriculum Developers

Since teachers are ultimately responsible for the instruction in their classrooms, sometimes they are the developers of school- or classroom-based curriculum and instructional materials, or are engaged in the selection of pre-made materials that can serve the needs of their classrooms. In either case, school-based curriculum developers can use the Example Bundles and descriptions of the bundling process as examples of how other teachers have thought about bundling PEs, as a tool for reflecting on their own instructional units, and as a source of ideas for the things to consider when beginning the process of curriculum development. By engaging with the Example Bundles, teachers will also be better prepared to evaluate instructional materials.

School and District Leaders

Bundling is a first step in translating the vision of the NGSS into curriculum and then into instruction. To support the development of NGSS-aligned curriculum, school and district leaders need to be aware of the implications of the NGSS and the process of bundling, even if they are not directly involved in the development process. Though not always directly engaged in curriculum development, school and district leaders enable the development work through their common understanding of the complexity of and time required for the process. District curriculum coordinators and others involved in district curriculum development can use the Example Bundles and descriptions of the bundling process as inspiration for developing their own bundles. Administrators can also use the Example Bundles in other ways, such as for helping teachers better understand the NGSS, or as a tool to help jump start school or district professional learning communities.

Publishers and Commercial Instructional Material Developers

Since the release of the NGSS in 2013, high-quality instructional materials designed for the NGSS have been a critical need in the science education community. Choosing from commercial products is one way that schools fill this need. The Example Bundles may hold much of the same value for publishers that they offer to schools and districts by presenting examples of ways to organize the NGSS. Additionally, by illustrating some of the early steps related to developing NGSS-designed curriculum, the Example Bundles can provide publishers with a common language to use with educators.

Back to the Table of Contents

Acknowledgements: Example Bundle Authors and Contributors

In a process coordinated by Achieve, the following scientists and education professionals worked together to develop the Example Bundles. The titles below indicate their positions at the time of development.

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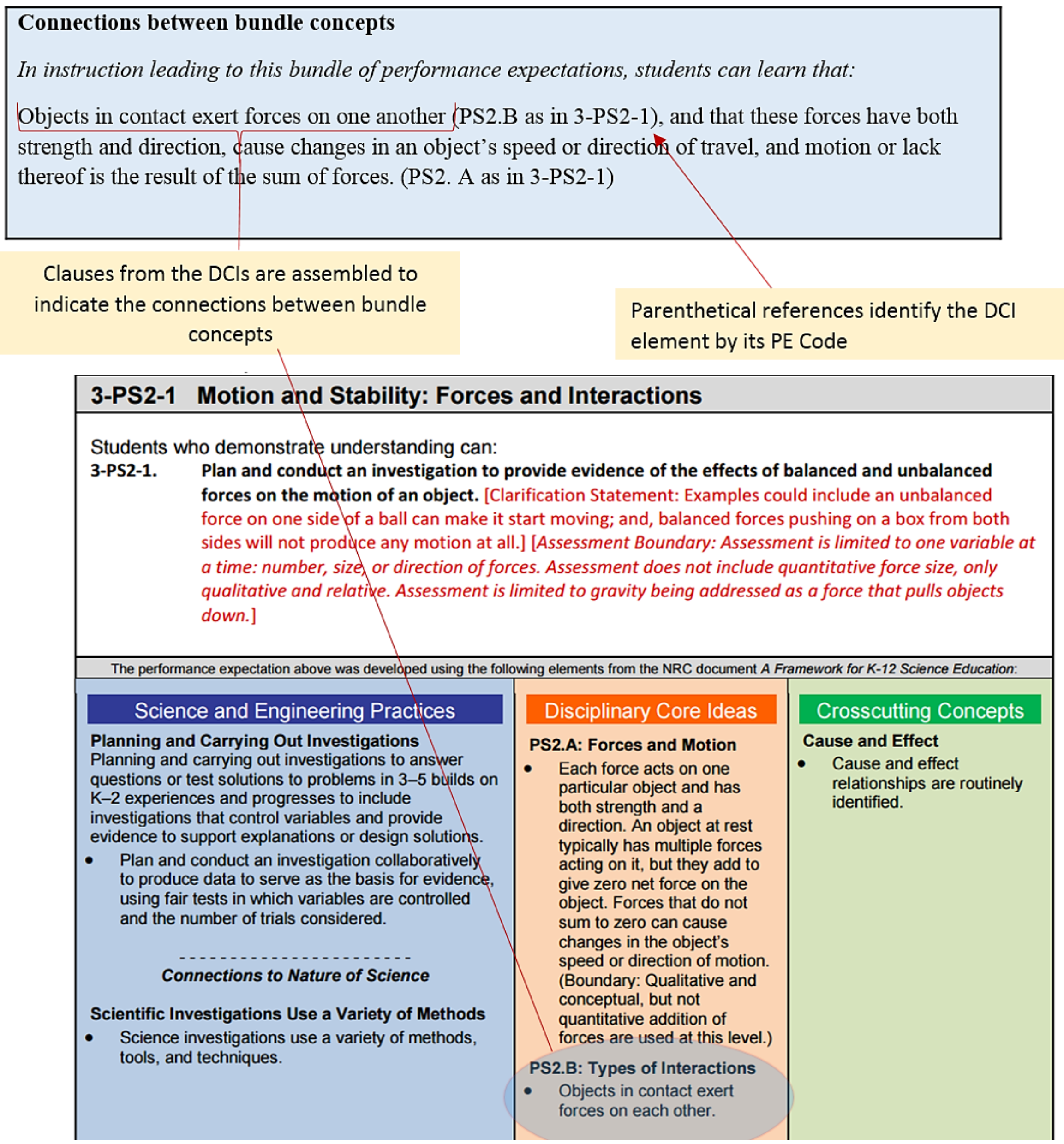
Back to the Table of Contents

Appendix 1: Example Bundle Styles and Explanations

A Note about the Style of the Example Bundle Document

Fidelity to the language of the NGSS is a driving design principle of the Example Bundles. Wherever possible, direct quotes of NGSS language, such as clauses of the PEs or DCI, CCC, and SEP elements are used in identifying connections between the PEs. This language is identified with specific type styles, such as italics when using SEP language in the additional SEPs section, and with parenthetical references that identify the relevant PE code. Non-NGSS or paraphrased language is used as sparingly as possible; only where absolutely necessary to demonstrate connections between PEs or to offer suggestions for instruction.

Figure 9: *An excerpt from a 3rd grade bundle is shown along with its source material in 3-PS2-1.*



Connections between bundle concepts

In instruction leading to this bundle of performance expectations, students can learn that:

Objects in contact exert forces on one another (PS2.B as in 3-PS2-1), and that these forces have both strength and direction, cause changes in an object's speed or direction of travel, and motion or lack thereof is the result of the sum of forces. (PS2. A as in 3-PS2-1)

3-PS2-1 Motion and Stability: Forces and Interactions

Students who demonstrate understanding can:

3-PS2-1. **Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.** [Clarification Statement: Examples could include an unbalanced force on one side of a ball can make it start moving; and, balanced forces pushing on a box from both sides will not produce any motion at all.] [*Assessment Boundary: Assessment is limited to one variable at a time: number, size, or direction of forces. Assessment does not include quantitative force size, only qualitative and relative. Assessment is limited to gravity being addressed as a force that pulls objects down.*]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations Planning and carrying out investigations to answer questions or test solutions to problems in 3–5 builds on K–2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions. • Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. - ***Connections to Nature of Science*** **Scientific Investigations Use a Variety of Methods** • Science investigations use a variety of methods, tools, and techniques.	**PS2.A: Forces and Motion** • Each force acts on one particular object and has both strength and a direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in the object's speed or direction of motion. (Boundary: Qualitative and conceptual, but not quantitative addition of forces are used at this level.) **PS2.B: Types of Interactions** • Objects in contact exert forces on each other.	**Cause and Effect** • Cause and effect relationships are routinely identified.

Bundle Summary

Figure 10: *An image from the Bundle Summary of a Kindergarten bundle document*

Bundle 1 Question: This bundles is assembled to address the questions of "How do objects move and what happens when they interact?"

Summary
The bundle organizes performance expectations around the topic of *pushes and pulls.* Instruction developed from this bundle should always maintain the three-dimensional nature of the standards, but recognize that instruction is not limited to the practices and concepts directly linked with any of the bundle performance expectations.

Connections between bundle DCIs
Pushing or pulling on an object can change the speed or direction of its motion and can start or stop it (PS2.A as in K-PS2-1 and K-PS2-2). This concept of motion connects to the idea that a bigger push or pull makes things speed up or slow down more quickly (PS3.C as in K-PS2-1).

The concept of pushing or pulling on an object (PS2.A as in K-PS2-1 and K-PS2-2) also connects to the idea that when objects touch, or collide, they push on one another and can change motion. (PS2.B as in K-PS2-1)

The idea that a bigger push or pull makes things speed up or slow down more quickly (PS3.C as in K-PS2-1) connects to the concept that pushes and pulls can have different strengths and directions (PS2.A as in K-PS2-1 and K-PS2-2).

The concept that people measure weather conditions to describe and record the weather and to notice patterns over time (ESS2.D as in K-ESS2-1) connects to the idea that it is useful to compare and test designs (ETS1.C as in K-2-ETS1-3) through data analysis.

The ideas that a situation that people want to change or create can be approached as a problem to be solved through engineering (ETS1.A as in K-PS2-2) and that, because there is always more than one possible solution to a problem, it is useful to compare and test designs (ETS1.C as in K-2-ETS1-3) could connect to multiple physical science concepts in this bundle. For example, these concepts could connect to the idea that when objects touch or collide, they push on one another and can change motion (PS2.B as in K-PS2-1) through a task in which students are challenged to work in groups to change the direction or speed of a ball with another object and then test and compare each group's solution. Alternatively, these engineering concepts could connect to the idea that a bigger push or pull makes things speed up or slow down more quickly (PS3.C as in K-PS2-1) through a different task in which students are asked to pull or push an object in a certain amount of time and then challenged to do it faster. Students could then compare their solutions and reflect on how their pull or push needed to change in order to move the object faster.

Bundle Science and Engineering Practices
Instruction leading to this bundle of PEs will help students build toward proficiency in elements of the practices of planning and carrying out investigations (K-PS2-1); and analyzing and interpreting data (K-PS2-2, K-ESS2-1, and K-2-ETS1-3). Many other practice elements can be used in instruction.

Engineering, Technology, and Applications of Science (ETS) DCIs Paired with Science DCIs

The integration of engineering design with science is a goal of the NGSS. When an Engineering, Technology, and Applications of Science (ETS) DCI is part of an example bundle, it is paired with some of the science concepts of the bundle. For example:

> *"...the concept that tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved (ETS1.B as in 3-5-ETS1-3) could connect to several concepts such as objects in contact exert forces on one another (PS2.B as in 3-PS2-1), or the idea that forces from electric and magnetic forces (PS2.B as in 3-PS2-3 and 3-PS2-4) come from objects. These connections could be made through an engineering design task such as designing a mechanical or a magnetic door latch to prevent a door from swinging open. Alternatively, students could be challenged with a different design task involving tests (ETS1.B as in 3-5-ETS1-3) that use patterns in motion to predict future motion (PS2.A as in 3-PS2-2) such as creating and testing a set of ramps designed to stop toy car rolling down a slope, modeling the challenges faced by vehicles whose brakes have failed as they descended a steep grade."*

Additionally, several examples are provided to indicate what the ETS DCI might look like during instruction.

Bundle Science and Engineering Practices and Bundle Crosscutting Concepts

To emphasize that the SEP and CCC elements of the bundle PEs are part of instruction, the summary section concludes with a listing of their titles and accompanying PE codes. Note that these are the student goals for *the end of instruction*—these are NOT the only SEPs and CCCs that could or should be used *during* instruction. An educator should not be limited by the SEP and CCC elements listed here, but rather should incorporate other SEP and CCC elements throughout instruction to ensure that all instruction is three-dimensional.

Bundle Performance Expectation Chart

The PE chart for a given bundle of PEs identifies the PE code, PE text, Assessment Boundary, and Clarification Statement associated with a given PE.

Figure 11: *A Performance Expectation chart from a Kindergarten Example Bundle*

Performance Expectations	K-PS2-1 **Plan and conduct an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object. [Clarification Statement: Examples of pushes or pulls could include a string attached to an object being pulled, a person pushing an object, a person stopping a rolling ball, and two objects colliding and pushing on each other.] [*Assessment Boundary: Assessment is limited to different relative strengths or different directions, but not both at the same time. Assessment does not include non-contact pushes or pulls such as those produced by magnets.*]** K-PS2-2 **Analyze data to determine if a design solution works as intended to change the speed or direction of an object with a push or a pull.* [Clarification Statement: Examples of problems requiring a solution could include having a marble or other object move a certain distance, follow a particular path, and knock down other objects. Examples of solutions could include tools such as a ramp to increase the speed of the object and a structure that would cause an object such as a marble or ball to turn.] [*Assessment Boundary: Assessment does not include friction as a mechanism for change in speed.*]** K-ESS2-1 **Use and share observations of local weather conditions to describe patterns over time. [Clarification Statement: Examples of qualitative observations could include descriptions of the weather (such as sunny, cloudy, rainy, and warm); examples of quantitative observations could include numbers of sunny, windy, and rainy days in a month. Examples of patterns could include that it is usually cooler in the morning than in the afternoon and the number of sunny days versus cloudy days in different months.] [*Assessment Boundary:***

	***Assessment of quantitative observations limited to whole numbers and relative measures such as warmer/cooler.*]** K-2-ETS1-3 **Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.**

Example phenomena

The example phenomena shown in this section are sample engaging phenomena that could be used in instruction, whether as an anchor for a unit or a driver for a lesson. Lines of student inquiry about these phenomena could drive instruction toward the bundle of PEs. However, these are not the only phenomena that could be used.

Figure 12: *An Example Phenomena chart from a Kindergarten Example Bundle*

Example Phenomena	A swing moves as it is pushed. A box pushed across a floor moves quickly with a strong push and slows down as when the pushing becomes weaker.

Additional Science and Engineering Practices Building to the PEs

This section demonstrates how additional SEPs—other than those already included in the bundle PEs—can support instruction. These additional SEPs are only examples and are not intended to be summatively assessed.

Figure 13: *An excerpt from the chart of Additional Practices Building to the PEs from a Kindergarten Example Bundle*

Additional Practices Building to the PEs	**Asking questions and defining problems** ● Ask and/or identify questions that can be answered by an investigation. Students could *identify questions about* **pushing or pulling on an object** *[to]* **change the speed or direction of its motion and can start or stop it** *that can be answered by an investigation.* K-PS2-1 and K-PS2-2

In this section, an SEP element is included from each of the eight SEP categories. Below the SEP element, a statement is included that shows a possible connection between the element and a DCI from one of the bundle PEs. The statement uses italics to identify SEP language and bold italics to identify DCI language. Additional phrases, included to increase the readability of the resulting statement, but not found in either the original DCI or SEP language, are set off with brackets, [].[8]

Additional Crosscutting Concepts Building to the PEs

Additional CCCs—other than those already included in the bundle PEs—are offered to help demonstrate the large number of options available to teachers to help students identify connections between ideas and engage in sense-making. These additional CCCs are only examples and are not intended to be summatively assessed.

Figure 14: *An excerpt from the chart of Additional Crosscutting Concepts Building to the PEs*

Additional Crosscutting Concepts Building to the PEs	**Patterns** ● Patterns in the natural and human designed world can be observed, used to describe phenomena, and used as evidence. Students could *observe patterns* ***of motion*** *and use these patterns as evidence* ***[of how] pushing or pulling on an object can change the speed or direction of its motion and can start or stop it***. K-PS2-1 and K-PS2-2

In this section, a CCC element is included for at least three of the seven CCCs. Below the CCC element, a statement shows a possible connection between the element and a DCI from one of the bundle PEs. The statement uses italics to identify CCC language and bold italics to identify DCI language. Plain text is used to show the suggested student action. Additional phrases, included to increase the readability of the resulting statement, but not found in either the original DCI or CCC language, are set off with brackets, [].[9]

[8] As stated in the NGSS Appendix F, "[I]t is too much to expect each performance to reflect all components of a given practice. The most appropriate aspect of the practice is identified for each performance expectation (in the NGSS foundation boxes for each PE)." (NGSS Appendices p. 50) Therefore, there are slight wording differences between some SEP elements in Appendix F of the NGSS and the appearance of those same elements when placed in context with PEs in the foundation boxes.

[9] As stated in the NGSS Appendix G, "Most performance expectations reflect only some aspects of a crosscutting concept. These aspects are indicated in the right-hand foundation box in each standard. All aspects of each core idea considered by the writing team can be found in the matrix [at the end of Appendix G]." (NGSS Appendices p. 80) Therefore, there are slight differences between some CCC elements in Appendix G of the NGSS and the appearance of those same elements when placed in context with PEs in the displays of the standards.

Additional Connections to Nature of Science

Additional NOS connections—other than those that may already be present in the bundle PEs—are offered to help demonstrate the large number of options available to teachers. These additional NOS connections are examples only and are not intended to be summatively assessed.

Figure 15: *An excerpt from the chart of Additional Connections to Nature of Science*

Additional Connections to Nature of Science	**Scientific investigations use a variety of materials** ● Scientific investigations begin with a question. Students could *begin a scientific investigation with a question* ***[about how] pushing or pulling on an object can change the speed or direction of its motion and can start or stop it*** and then reflect on the fact that their *investigation began with a question.* K-PS2-1 and K-PS2-2.

Below the NOS connection is a statement that shows a possible connection between the NOS idea, and a DCI and SEP from the bundle PEs. The statement uses italics to identify NOS language and bold italics to identify DCI language. Plain text shows the suggested student action. The PE code associated with the DCI is included to provide easier identification of the DCI within NGSS documents. Additional phrases, included to increase the readability of the resulting statement, but not found in either the original bundle PE, DCI, CCC, or suggested NOS language, are set off with brackets, [].

Evidence Statements

Evidence statements shown in the bundles always describe summative assessment of a given PE or part of a PE. *PEs may be broken up across several bundles* or even between courses in middle and high school, with instruction focusing on different components of a PE in different bundles. In such cases, different observable components of the evidence statements are highlighted in each bundle. Across the scope of the grade level or grade band of PEs, all of the observable components are addressed.

Figure 16: *The Evidence Statement for HS-PS2-4. The black text show the goals for one bundle and the grayed-out sections are goals for a later bundle (in this case, in the following year of instruction).*

Observable features of the student performance by the end of the course:		
1	Representation	
	a	Students clearly define the system of the interacting objects that is mathematically represented.
	b	Using the given mathematical representations, students identify and describe* the gravitational attraction between two objects as the product of their masses divided by the separation distance squared $\left(F_g = -G\frac{m_1 m_2}{d^2}\right)$, where a negative force is understood to be attractive.
	c	Using the given mathematical representations, students identify and describe* the electrostatic force between two objects as the product of their individual charges divided by the separation distance squared $\left(F_e = k\frac{q_1 q_2}{d^2}\right)$, where a negative force is understood to be attractive.
2	Mathematical modeling	
	a	Students correctly use the given mathematical formulas to predict the gravitational force between objects or predict the electrostatic force between charged objects.
3	Analysis	
	a	Based on the given mathematical models, students describe* that the ratio between gravitational and electric forces between objects with a given charge and mass is a pattern that is independent of distance.
	b	Students describe* that the mathematical representation of the gravitational field $\left(F_g = -G\frac{m_1 m_2}{d^2}\right)$ only predicts an attractive force because mass is always positive.
	c	Students describe* that the mathematical representation of the electric field $\left(F_e = k\frac{q_1 q_2}{d^2}\right)$ predicts both attraction and repulsion because electric charge can be either positive or negative.
	d	Students use the given formulas for the forces as evidence to describe* that the change in the energy of objects interacting through electric or gravitational forces depends on the distance between the objects.

Back to the Table of Contents

Appendix 2: Further Reading on Three-Dimensional Instruction

Bundling standards is only one part of the work needed to develop three-dimensional curriculum, lesson plans, and instructional strategies. For further reading on these topics, the resources listed below might be helpful. Many states also develop their own guidance about these issues.

Research and Visioning Documents

- A *Framework* for K-12 Science Education: www.nap.edu/catalog/13165/a-framework-for-k-12-science-education-practices-crosscutting-concepts
- Next Generation Science Standards: www.nextgenscience.org
- Taking Science To School: http://www.nap.edu/catalog/11625/taking-science-to-school-learning-and-teaching-science-in-grades. Includes much of the research underlying the NRC Framework and the NGSS, as well as descriptions of students' commonly held ideas.
- Ready, Set, SCIENCE: http://www.nap.edu/catalog/11882/ready-set-science-putting-research-to-work-in-k-8. The practitioners guide to Taking Science To School

Sources of a Wide-Range of Implementation Support and Resources

- Guide to Implementing the NGSS: http://www.nap.edu/catalog/18802/guide-to-implementing-the-next-generation-science-standards. A document from the National Research Council
- NGSS website resource library: http://nextgenscience.org/resource-library
- NGSS@NSTA website: ngss.nsta.org
- STEM Teaching Tools: http://stemteachingtools.org/

Unpacking the NGSS

- NGSS Evidence Statements: http://nextgenscience.org/evidence-statements

Resources for Equitable Instructional Strategies

- NGSS Appendix D and its accompanying case studies: http://nextgenscience.org/appendix-d-case-studies
- NGSS for All Students: www.nsta.org/store/product_detail.aspx?id=10.2505/9781938946295. Case studies of research- and standards-based classroom strategies for engaging diverse student groups.

Criteria for NGSS-aligned Instructional Materials

- EQuIP Rubric: www.nextgenscience.org/equip. Provides criteria for measuring quality and NGSS-design of lessons and units
- PEEC tool: www.nextgenscience.org/peec. NGSS Publishers Criteria, providing criteria for measuring NGSS design of year-long or multi-year instructional materials

Resources for Developing Instructional Materials Designed for the NGSS

- www.nextgenstorylines.org
- Paper on Designing Coherent Storylines Aligned with NGSS for the K–12 Classroom: hwww.academia.edu/6884962/Designing_Coherent_Storylines_Aligned_with_NGSS_for_the_K-12_Classroom
- Paper on Planning Instruction to Meet the Intent of the Next Generation Science Standards: http://link.springer.com/article/10.1007/s10972-014-9383-2

Information about Middle and High School Course Models

- NGSS Appendix K: http://nextgenscience.org/sites/default/files/Appendix K_Revised 8.30.13.pdf

Back to the Table of Contents