MIDDLE SCHOOL SCOPE & SEQUENCE

Updated 4/26/21

Overview

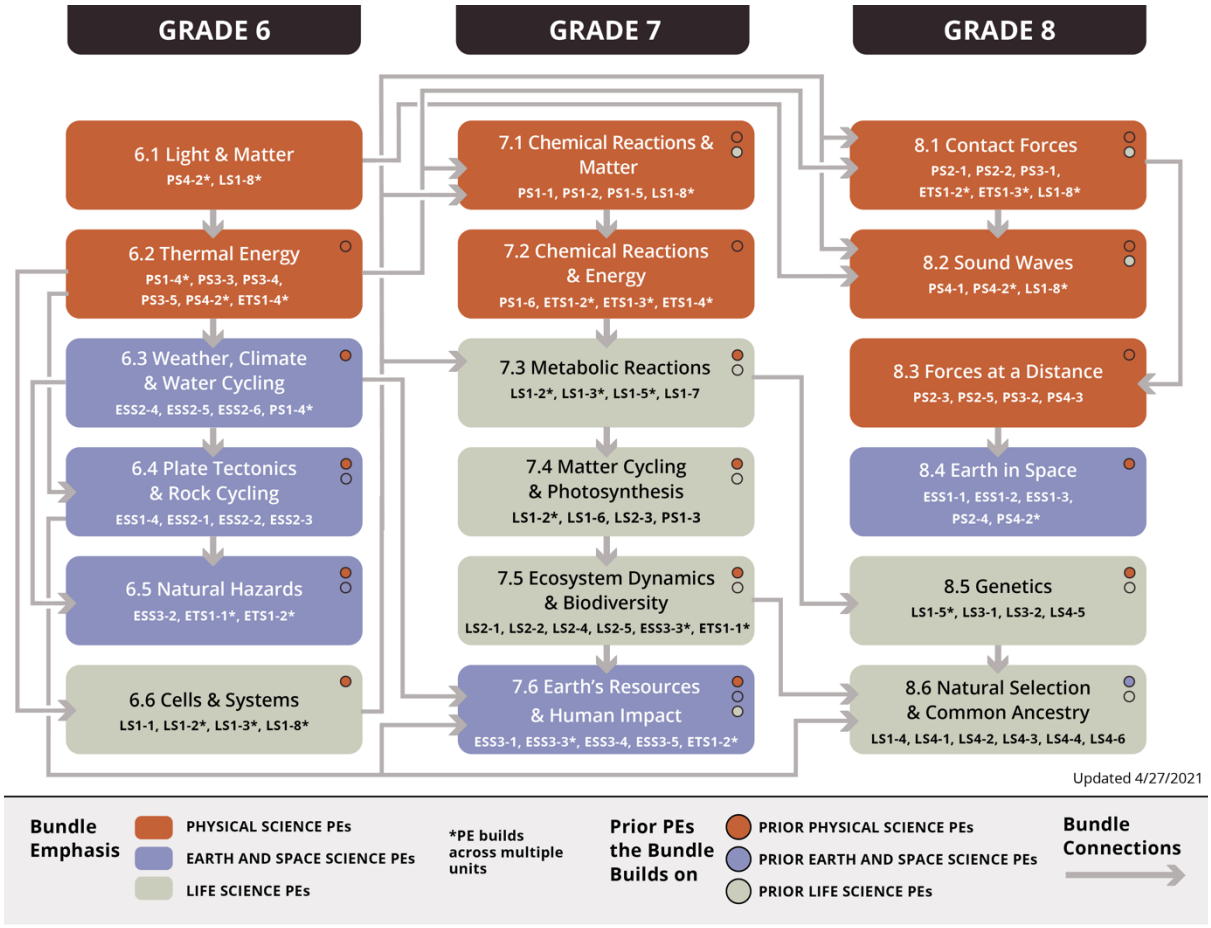
This document contains a description of the *OpenSciEd Middle School Program Scope and Sequence*. The scope and sequence articulates how the middle school program is organized in bundles of performance expectations used to design a target unit, how the ideas in each unit build on prior ideas, and how the three dimensions of NGSS are reflected in these PE bundles. This document includes the following components of the scope and sequence for the middle school program:

1. *Disciplinary Core Ideas Connections:* The first view shows how the NGSS performance expectations (PEs) are organized into bundles, and how the disciplinary core ideas (DCIs) build across these PE bundles. These were the primary considerations in the design of the scope and sequence for the program. (The rationale for these decisions is outlined in a separate white paper, available soon.)
2. *Focal Science and Engineering Practices (SEPs):* This table indicates the focal SEPs for each unit. These are the SEPs that play a major role in explaining phenomena and solving problems in the unit.
3. *Focal Crosscutting Concepts (CCCs):* This table indicates the focal CCCs for each unit. These are the CCCs that are central in explaining phenomena and solving problems in the unit.
4. *Units Addressing PE Bundles:* This table presents brief descriptions of the key phenomena, questions, and what students figure out in each PE bundle. The planned development cycle for OpenSciEd units reflecting each bundle is listed, along with the titles for those units that have been developed so far.

Disciplinary Core Ideas Connections

The DCI connections map shows each PE bundle as an object in the diagram. Connections are shown as arrows. A connection means more than a simple prerequisite relationship. If two PE bundles are connected, e.g., 6.2 to 6.4, that means that the unit designed for the second PE bundle (6.4) should explicitly involve students in revisiting and discussing what they figured out about the particular DCIs as they work on figuring out phenomena in this current unit. Students' new models in 6.4 will explicitly and revise or extend the prior versions of some disciplinary core ideas from 6.2.

The connections between PE bundles may be within a DCI strand or between strands. (See the key for details; See Appendix A for a summary of the decisions used in this DCI sequence.)



Focal Science and Engineering Practices

The “Focal science and engineering practices” (SEPs) are the SEPs on which the unit focuses. These are the SEPs that play a major role in explaining phenomena and solving problems in the unit. Of course, the NGSS SEPs work together to support explaining phenomena and solving problems, so each unit typically brings in other SEPs as needed.

Like the DCIs, these practices are used and built incrementally across units. The symbol "✓✓” indicates a focal practice for which the unit includes explicit supports to further develop elements of the practice. The symbol “✓” indicates a focal practice used in the unit, but for which further development of elements of the practice are not targeted.

Note: These tables represent our current plan. The focal practices may change as each unit is developed without necessitating changes in the composition or order of the PE bundles.

Grade 6 Focal SEPs

Unit	Asking Questions & Defining Problems	Developing & Using Models	Planning & Carrying Out Invest.	Analyzing & Interpret. Data	Using Math & Comp. Thinking	Construct. Explanation & Designing Solutions	Engaging in Argument from Evidence	Obtaining, Evaluating & Comm. Info.
6.1	✓✓	✓				✓		✓
6.2		✓	✓✓			✓✓	✓	
6.3		✓✓	✓✓	✓✓				
6.4		✓✓			✓✓	✓✓		
6.5				✓	✓✓	✓		✓✓
6.6		✓	✓				✓	

Grade 7 Focal SEPs

Unit	Asking Questions & Defining Problems	Developing & Using Models	Planning & Carrying Out Invest.	Analyzing & Interpret. Data	Using Math & Comp. Thinking	Construct. Explanation & Designing Solutions	Engaging in Argument from Evidence	Obtaining, Evaluating & Comm. Info.
7.1		✓	✓	✓✓		✓✓		
7.2			✓			✓✓		
7.3		✓✓		✓			✓✓	
7.4		✓				✓	✓✓	✓✓
7.5	✓	✓	✓✓		✓✓	✓		
7.6	✓	✓		✓	✓	✓	✓	

Grade 8 Focal SEPs

Unit	Asking Questions & Defining Problems	Developing & Using Models	Planning & Carrying Out Invest.	Analyzing & Interpret. Data	Using Math & Comp. Thinking	Construct. Explanation & Designing Solutions	Engaging in Argument from Evidence	Obtaining, Evaluating & Comm. Info.
8.1			✓✓	✓		✓✓	✓	
8.2		✓✓			✓		✓✓	
8.3	✓✓	✓	✓					
8.4		✓✓		✓		✓		✓
8.5		✓			✓✓			✓✓
8.6				✓✓		✓✓	✓✓	

Focal Crosscutting Concepts

The "Focal Crosscutting Concepts" (CCCs) are the CCCs on which the unit focuses. These are the CCCs that play a major role explaining the phenomena and solving problems in the unit. Units typically bring in other crosscutting concepts, as appropriate, in addition to these focal ones.

Note: These tables represent our current plan. The focal CCCs may change as each unit is developed without necessitating changes in the composition or order of the PE bundles.

Grade 6 Focal CCCs

Unit	Patterns	Cause & Effect	Scale, Proportion, Quantity	Systems, System Models	Energy, Matter	Structure & Function	Stability & Change
6.1				✓		✓	
6.2				✓	✓	✓	
6.3	✓	✓		✓	✓		
6.4	✓	✓	✓				✓
6.5		✓	✓				✓
6.6						✓	✓

Grade 7 Focal CCCs

Unit	Patterns	Cause & Effect	Scale, Proportion, Quantity	Systems, System Models	Energy, Matter	Structure & Function	Stability & Change
7.1	✓		✓		✓		
7.2				✓	✓		
7.3				✓		✓	
7.4				✓	✓		
7.5		✓		✓			✓
7.6		✓	✓	✓			✓

Grade 8 Focal CCCs

Unit	Patterns	Cause & Effect	Scale, Proportion, Quantity	Systems, System Models	Energy, Matter	Structure & Function	Stability & Change
8.1				✓	✓	✓	✓
8.2	✓		✓				
8.3		✓		✓			
8.4	✓		✓	✓			
8.5		✓				✓	
8.6	✓	✓				✓	✓

Units Addressing PE Bundles – Grade 6

Unit	PE Bundle Name	PE Bundle Description	Unit Name
6.1	Light & Matter	Students explain how light interacts with matter, including how it can be absorbed, transmitted, or reflected by different materials.	*Why do we sometimes see different things when looking at the same object?*
6.2	Thermal Energy	Students develop a particle level model of thermal energy transfer within materials and between materials, for solids, liquids, and gases. They apply the science ideas they figure out to design a device that slows thermal energy transfer.	*How can containers keep stuff from warming up or cooling down?*
6.3	Weather, Climate & Water Cycling	Students investigate the natural movement and distribution of water on the planet. Students figure out that precipitation patterns depend on geographic location (e.g., latitude, proximity to large bodies of water, altitude). Students explain patterns in weather and climate in terms of temperature patterns, humidity, and precipitation and develop the key mechanism in these processes of convection.	*Why does a lot of hail, rain, or snow fall at some times and not others?*
6.4	Rock Cycling & Plate Tectonics	Students investigate changes on the Earth's surface, and figure out how geographic location (proximity to plate boundaries) determines the type of landforms near one's communities and the distribution of rocks and fossils. Students develop models for the cycling of matter and movement of plates to explain earthquakes, volcanoes, and changes in the Earth across geological time scales.	*How and why does Earth's surface change?*
6.5	Natural Hazards	Students use what they figured out in 6.3 and 6.4 to investigate how these natural processes can affect and shape human communities. Students investigate how earthquakes, tsunamis, volcanic eruptions, and catastrophic weather can be forecasted and how communities can plan to mitigate the effects of these hazards.	*Where do natural hazards happen and how do we prepare for them?*
6.6	Cells & Systems	Students investigate what is needed at the cellular and systems level for a multicellular organism to survive. Students use evidence to support the idea that living things are made of cells, and explain how the cells' and body system's structure and function contribute to the organism's ability to function.	*How do living things heal?*

Units Addressing PE Bundles – Grade 7

Unit	PE Bundle Name	PE Bundle Description	Unit Name
7.1	Chemical Reactions & Matter	Students develop and use a model of atoms and molecules to represent different substances and how they are rearranged and mass is conserved in chemical reactions. Students investigate property changes in the stuff they have before and after a chemical reaction and after a phase change to argue for whether new substances are created in these processes.	*How can we make something new that was not there before?*
7.2	Chemical Reactions & Energy	Students develop a model of energy transfer in chemical reactions and design a device to transfer the thermal energy produced from a chemical reaction to other parts of a system.	*How can we help people make a flameless heater?*
7.3	Metabolic Reactions	Students build on their model of energy and chemical reactions to explain how humans and other animals get the energy they need to survive and the building blocks to grow from the food that they eat. Students explain how this matter and energy transfer occurs as cells can make new substances out of food molecules through chemical reactions.	*How do things inside our bodies work together to make us feel the way we do?*
7.4	Matter Cycling & Photosynthesis	Students build on their model of energy and matter in food to investigate how food molecules become a part of the food they eat (both natural and processed foods). Students investigate how plants make food molecules and the source of the matter and energy needed for this process to do this. Students develop a model to explain that the major atoms that make up food (carbon, hydrogen, and oxygen) are continually recycled between biotic and abiotic parts of our world.	*Where does food come from, and where does it go next?*
7.5	Ecosystem Dynamics	Students investigate how interactions among organisms and changes to the environment (e.g. resource availability) can affect population sizes. Students develop a model including different type of relationships (competitive, predatory, etc.), and biotic/abiotic interactions to explain stability and change in ecosystems.	*How does changing an ecosystem affect what lives there?*

7.6	Natural Resources & Human Impact	Students investigate the uneven distribution of water, mineral, and fossil fuel resources on the planet. Students investigate how increase in human populations and per-capita resource consumption affects Earth's natural systems (climate, biosphere) in potentially hazardous ways. Students investigate natural carbon sinks, carbon sources, and the movement of carbon from fossil fuels into the atmosphere. Students develop a model of changes in the Earth's climate system, and design systems to mitigate human effects on natural systems.	*How do changes in Earth's system impact our communities and what can we do about it?*

Units Addressing PE Bundles – Grade 8

Unit	PE Bundle Name	PE Bundle Description	Unit Name
8.1	Contact Forces	Students investigate causes of motion, and develop the idea that objects that collide can push on one another while they are in contact. Students connect the changes in the kinetic energy of an object to the energy being transferred to and from the object due to forces, and determine that the kinetic energy of an object is based on the two factors of mass and speed.	*Why do things sometimes get damaged when they hit each other?*
8.2	Sound Waves	Students investigate how the frequency and amplitude of a sound wave can explain other macroscopic phenomena (loudness and pitch of a sound). Students explain at the molecular level how the deformation of materials results in oscillations that lead to the propagation of collisions of particles across a medium, and how the amplitude of the vibration is related to the energy of the wave.	*How can a sound make something move?*
8.3	Forces at a Distance	Students explain how at-a-distance forces transfer energy between interacting objects in a system as the objects change position. This involves developing the idea of potential energy stored in systems of objects (e.g., magnets) and the transfer of this potential energy to the movement of objects depending on the objects' position and orientation to each other.	*How can a magnet move another object without touching it?*
8.4	Earth in Space	Students investigate force and motion of objects in space, and how forces that act in a direction perpendicular to the motion of the object can lead to circular patterns of motion (an orbit). Students develop a model using gravity to explain	*Why do we see patterns in the sky, and what else is*

		patterns of motion of the earth, sun, moon, other planets and their moons, stars in our galaxy, and other galaxies. Students also investigate differences in the composition and surface features (crust, atmosphere, volcanoes) of planets in the solar system.	*out there that we can't see?*
8.5	Genetics	Students investigate patterns in inheritance data to develop a model for how heredity information is encoded in genes on chromosomes, how these molecules affect traits through production of proteins, and how these molecules provide a mechanism for passing traits across generations. Students use their models to explain how variation arises in sexual reproduction and how patterns in heredity occur. Students models and use the model to explain how variations in genetic information can affect traits through production of proteins.	*Why are living things different from one another?*
8.6	Natural Selection & Common Ancestry	Students develop a model of natural selection that explains how trait distributions in populations shift over time. Students explore how differences between individuals and species' characteristics and behaviors enhance their fitness and how environmental changes can lead to shifts in trait distributions in a population over time. Students build on this model to investigate evidence from anatomical similarities and differences between organisms living today and organisms in the fossil record, and patterns in the traits of embryos from different species that are alive today, to extend a natural selection model to explain speciation.	*How could things living today be connected to the things that lived long ago?*

Appendix A: Summary of Heuristics Used to Construct the OpenSciEd Scope and Sequence

Step in Process	Heuristic	Description
1. Create PE bundles	***1a. Bundle related ideas***	Bundle PEs coherently so that students are bringing together related ideas to explain phenomena or solve problems.

	1b. Bundle PEs needed for mechanisms	Explain large scale macroscopic phenomena (weather, plate interactions, planetary motion) using mechanisms rather than facts and descriptions (e.g. figure out how gravity and motion explain why planets travel in elliptical orbits vs. just learning that planets travel in such orbits).
2. Draw Connections	***2a. Build explanations of phenomena using already established mechanisms***	Organize units so that mechanisms constructed in one unit can be used as explanatory mechanisms for subsequent units (e.g., build metabolic reactions on an earlier developed model of chemical reactions).
	2b. Refine ideas across time	Support students in using explanatory ideas (particularly DCIs) from an earlier unit again in new related contexts, revising and extending the ideas to address the new contexts. Articulate connections both within and between science strands, and both within and across grades.
	2c. Combine across disciplinary strands when needed for explanation	Don't integrate simply for the sake of integrating science strands. Combine ideas across strands when the additional disciplinary core ideas are needed to explain the mechanism at a grade-appropriate level.
3. Group bundles into years	***3a. Sequence within and across grades to enable unit to unit connections***	Organize the units into a sequence within and across grades so that the sequence enables refining ideas across time as needed for the coherence articulated in steps 2a and 2b.
	3b. Use grade-level math	Don't place PEs that require common core math before the grade at which the math ideas will be developed.
	3c. Engineering across grades	Use and revisit different combinations of the four MS-ETS PEs in each grade (specifics TBD).
	3d. Balance Science Strands	Ensure that each of the three science strands - earth & space, physical, and life sciences are relatively balanced in each grade.
	3e. Balance Grades	Balance the number of PEs and the time to address them across the 3 grades. Be careful not to put too many complex PEs in grade 6.