California Department of Education
California Next Generation Science Standards
April 2015
Integrated Learning Progression Overview

On September 4, 2013, the State Board of Education (SBE) adopted the *Next Generation Science Standards for California Public Schools, Kindergarten through Grade Twelve* (CA NGSS) as required by California *Education Code* 60605.85. The CA NGSS is based upon the nationally developed Next Generation Science Standards (NGSS).

The NGSS present middle grade standards in a grade span of sixth through eighth grades. The SBE is constitutionally and statutorily obligated to adopt instructional materials for kindergarten through grade eight, which requires that standards be placed at specific grade levels. Therefore, the State Superintendent of Public Instruction recommended the adoption of the placement of these original NGSS standards at each grade level as described in the document below. On November 6, 2013, the SBE adopted the (preferred) Integrated Learning Progression Courses for Middle Grades Six through Eight (integrated progression). The integrated progression was developed by the Science Expert Panel (SEP), a group made up of kindergarten through grade twelve teachers, scientists, educators, business, industry representatives, and informal science educators. Feedback was provided by:

1) The SEP meetings took place on April 22, 2013, April 23, 2013, May 13–14, 2013, and June 3–4, 2013; all meetings were open to the public.

2) The California Department of Education and the California Comprehensive Center facilitated three regional public meetings for members of the public to submit feedback on the NGSS: April 29, 2013, in Mather, CA; April 30, 2013, in San Jose, CA (this meeting was also broadcasted via live webinar); and May 2, 2013, in Riverside, CA.

The SEP used the following criteria to arrange the Performance Expectations (PEs) for grades six, seven, and eight:

1. PEs were placed at each grade level to support content articulation across grade levels (from grade five through grade eight) and provide the opportunity for content integration within each grade level.

2. PEs were aligned with the Common Core State Standards (CCSS) in English Language Arts (ELA) and Mathematics so that science learning could integrate with the CCSS and would not be dependent upon ELA and mathematics skills not yet acquired.

3. The final arrangement of PEs reflected a balance both in content complexity and number at each grade level with engineering performance expectations appropriately integrated.

4. **Human Impact (six–eight):** As a possible unifying theme, human impact can be addressed across disciplines and across grade levels. Embedded in the Earth and Space Science PEs is a relation to human impact. In sixth grade, a PE asks students to apply scientific principles to design a method for monitoring and minimizing a human impact on the environment. This links nicely with the concepts of weather and climate. In seventh grade, a PE highlights natural hazards. This provides the opportunity to investigate earthquakes in connection with plate tectonics. In eighth grade, a PE challenges students to think deeply about the consequences of human population growth and resource consumption. The PEs related to human impact allow students to understand how humans can impact natural systems and change patterns.

In addition to these criteria, the SEP worked to ensure that the performance expectations were arranged (bundled) together in various ways to facilitate curriculum development.

The chart below illustrates the SEP's vision for middle school articulation between grades (six, seven, and eight) within the disciplines, as well as opportunities for content integration across disciplines at each grade.

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<tr><td rowspan="5">Articulation →</td><td>8</td><td></td><td></td><td></td><td></td></tr>
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<tr><td>6</td><td colspan="4">→ Integration</td></tr>
<tr><td></td><td>Life</td><td>Earth/Space</td><td>Physical</td><td>Engineering Design</td></tr>
<tr><td colspan="6">Integration</td></tr>
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The order in which the PE in each discipline is listed does not imply the order of teaching or the instructional sequence. Bundling the PEs around specific topics within the science disciplines provides an organization of the content to which an instructor or educator can more easily focus instruction and then apply cross-cutting concepts reasoning to connect among topics in different disciplines. While many cross-cutting concepts could be used to organize the bundled PEs for each grade, the SEP identified topics for bundling as presented in the CA NGSS.

Grade Six TOPIC ARRANGEMENT FOR INTEGRATION

Bundling the PEs provides a topic view of the PEs to which an educator can more easily align crosscutting concepts as seen in this chart:

Grade	Cross Cutting Concepts	Life	Earth	Physical	Engineering
Sixth	Patterns; structure and function; systems and system models	Cells and Organisms	Weather and climate	Energy	Engineering Technology and Science Standards (ETS)

While many cross-cutting concepts could be used to organize the PEs for sixth grade, the SEP identified three: Systems and System Models, Patterns, and Structure and Function. Examples of how these cross-cutting concepts could be used to deepen and connect student understanding are presented below.

Systems and System Models

Systems and System Models is one of the cross-cutting concepts emphasized in sixth grade. A system is a well-defined set of interacting pieces/components, which work together to function as a whole. For example, each component of the system can be considered a subsystem with its own substructure and function. The way a system functions can be explained in the context of a model of the system and interactions between subsystems. The boundary of each system or subsystem may naturally occur, or may be artificially defined in order to simplify the model. When setting boundaries, it is always important to consider what flows or acts (external forces) across this boundary, as well as what happens within the system itself.

In grade six, life sciences PEs examine the system of cells and organelles, as well as body systems and subsystems. Students are asked to understand how these systems interact with one another and how specialized cells perform specific functions within systems. Sixth grade earth science addresses systems as related to the atmosphere and the ocean. The ocean and atmosphere are comprised of smaller subsystems, or regions, with varying temperatures, densities, volumes, and energy flows. Modeling these parameters helps students to understand climate patterns and describe how these patterns might change over time. The artificially defined boundaries between the subsystems are dynamic and continuously mix due to the flow of matter and energy within and between the atmosphere and ocean. For students, it is useful to be able to define the subsystems in order to describe and model patterns within the larger system. Patterns that students will describe and model include: prevailing winds, surface currents, and storm progress are all examples of patterns. The PEs related to human impact allow students to understand how humans can impact natural systems and change patterns.

Patterns

A second cross-cutting concept emphasized in sixth grade is patterns. Patterns are observable, repeated phenomena or cycles of a system. The PEs in sixth grade address patterns that repeat in time, in addition to patterns of similarity across objects (such as cells). The patterns include those of cell growth and division, and organisms' life cycles in life science, of water cycles, of climate and weather in earth science, and of the flow of energy in physical science. Humans can impact some of these patterns by introducing changes in conditions of the system.

Structure and Function

Structure and function is the third cross-cutting concept emphasized in sixth grade. Structure represents how objects (living or non-living) are shaped and made up of parts or substructures. The way a system functions depends on the structure of its parts or subsystems and their interactions (e.g., the relationship of shape of the cogs of bicycle gears to the shape of the links in the chain is critical to how the bicycle works). Structure and function are complementary. In the life sciences, cells, tissues, organs, organ systems, and organisms are examples of interrelated structures and functions, which can be analyzed and modeled to describe their relationships. In earth science, scientists model the atmospheres and ocean as composed of sub-structures, volumes or regions that differ in temperature and density and (for the atmosphere) humidity. These structures and their interactions help explain the functioning of ocean currents and weather patterns.

Grade Seven TOPIC ARRANGEMENT FOR INTEGRATION

Bundling the PEs provides a topic view of the PEs to which an educator can more easily align cross-cutting concepts as seen in this chart:

Grade	Cross Cutting Concepts	Life	Earth	Physical	Engineering
Seventh	Energy and Matter: flows, cycles, and conservation; cause and effect	Ecosystems	Natural resources	Structure and property of matter	ETS

While many cross-cutting concepts could be used to organize the performance expectations, the SEP identified two for seventh grade: 1) Energy and Matter: Flow, Cycles, and Conservation, and 2) Cause and Effect. Examples of how the cross-cutting concepts could be used to deepen and connect student understanding are presented below.

Energy and Matter

Energy and Matter: Flow, Cycles and Conservation is one of the cross-cutting concepts emphasized in seventh grade. Because both matter and energy are conserved, keeping track of how they enter, leave, flow or cycle within any system is a critical element of understanding how that system functions. Matter cycles are accompanied and driven by energy flows and energy transformations (e.g., from light to chemically stored energy in photosynthesis). Students will gain an understanding of energy and matter flow cycles by studying: photosynthesis, food webs, the rock cycle, and plate tectonics. Human Impact PEs encourage students to forecast matter and energy flow impacts in catastrophic events and consider how human actions can reduce or increase their impact.

Cause and Effect

Cause and Effect is the second cross-cutting concept emphasized in seventh grade. Students will seek to understand mechanisms of cause and effect and how particular actions on, or conditions of, a system influence the way it functions (what occurs). Through the life sciences PEs, students will demonstrate an understanding of how the abiotic (or non-living) factors in an ecosystem impact the biotic (or living) organisms found in an ecosystem. Related to earth science, students will learn how tectonic plate movement is caused by the deeper cycling of Earth's materials and the flow of energy that drives this process within the geosphere. This tectonic process and flow of energy has the effect of continually generating new ocean sea floor at ridges and destroying old sea floor at trenches. This process leads to ocean floor spreading, and mountain uplifts, as well as, volcanism and earthquake activity. Related to physical science, the concept of cause and effect is seen in the context of natural or designed systems where a condition (temperature and pressure) and proportions of reactants affect whether a chemical reaction occurs and what products result. The PEs related to human impact allow students to consider how human choices can alter conditions, such as where housing should be placed in order to lessen the impacts of catastrophic events.

Grade Eight TOPIC ARRANGEMENT FOR INTEGRATION

The bundling of the PEs in eighth grade by topic is illustrated in this chart below:

Grade	Cross Cutting Concepts	Life	Earth	Physical	Engineering
Eighth	Stability and change; scale, proportion and quantity	Natural Selection	History of the Earth Space systems	Waves and Electro-magnetic radiation Energy Forces and Interactions	ETS

While many cross-cutting concepts could be used to organize the PEs, the SEP identified two cross-cutting concepts: Stability and Change, as well as Scale, Proportion and Quantity as examples of how the cross-cutting concepts could be used to deepen and connect student understanding.

Stability and Change

Stability and Change is one of the cross-cutting concepts emphasized in eighth grade. Stability in any system is a dynamic condition of balance between competing effects, which depends on the conditions of the system. A system is said to be stable when it can maintain its condition and function over extended periods of time, even though viewed on a longer time scale it is slowly changing. When conditions within, or forces acting on, a system change, the system may continue to function, change gradually, or undergo more sudden changes. A system may have a range of conditions under which it has stable function, or it can change catastrophically, such as, when a population collapses in an ecosystem. Gradual change over extended time is also emphasized in this cross-cutting concept for the eighth grade.

For example, the processes of natural selection, biological adaptation, examination of the fossil record, and evolution represent changes over extremely long periods of time. Similarly, by understanding change over long periods of time in the context of geosciences, students gain a better understanding of rock strata and the history of earth as well as, the evolution of the solar system and space. PEs related to the physical sciences emphasize understanding change on shorter time scales such as: change in position over time, the result of forces acting on objects, and movement of waves. Students learn to describe how objects, energy, or systems change on shorter time scales starting from an unstable condition with unbalanced forces (or non-equilibrium conditions) of motion or energy flows. An example of this can be seen when observing the motion of a pendulum or weight on a spring.

Scale, Proportion and Quantity

Scale, Proportion and Quantity is the second cross-cutting concept emphasized in eighth grade. In modeling any system as a set of subsystems, a student must choose the scale of space and time that needs to be modeled in order to understand the phenomena in question, such as choosing between the human body as a set of body systems or as a collection of cells. Students are asked to think of the system at different scales, be able to quantify aspects of the system, and consider how changes in scale affect proportions and quantities within it. Understanding units of measure is critical to this thinking.

When making sense of the universe in earth and space science the scale of time and space is huge, and in the life sciences, the fossil record/rock strata are best understood when linked through a long time scale. Students' mathematical understanding of the representation of large numbers and their conceptual understanding of the ratios of such numbers is critical to understanding these phenomena. Significant elements of the

eighth grade level science concepts include a conceptual understanding of: the relative sizes of objects (mass and volume), and the distances between them and an understanding of how gravitational interactions scale with distance. Also critical to interpreting and predicting motion within galaxies and the solar system are the concepts of: mathematical relationships or proportionalities among different types of physical quantities associated with an object (such as energy, mass, velocity, or distance from the ground). These concepts must be understood to interpret the magnitude of the energy associated with the object or system and how it changes when position or velocity changes. Similarly complex concepts for an eighth grade student to understand are: the amplitude of a wave is proportionally related to the energy that the wave is transporting, the frequency scale and wavelength have a proportional relationship between them, as wells as the speed of travel of the wave.

ARRANGEMENT FOR ARTICULATION

The chart below illustrates the topic arrangement of the PEs to link the learning progression from elementary through middle school in each discipline.

Grade	Cross cutting concepts	Life	Earth and Space	Physical	Engineering
Eighth	Stability and change; scale, proportion and quantity	Natural Selection	History of the Earth Space systems	Waves and Electro-magnetic radiation Energy Forces and Interactions	ETS
Seventh	Energy and Matter: flows, cycles, and conservation; cause and effect	Ecosystems	Natural resources	Structure and property of matter	ETS
Sixth	Patterns; structure and function; systems and system models	Cells and Organisms	Weather and climate	Energy	ETS
Fifth	Energy and Matter: flows, cycles and conservation; Scale, proportion and quantity	Matter cycles through living and non living things	Earth in space, interactions of earth systems	Properties and structure of matter	ETS

The chart above summarizes the progression of learning from fifth grade through eighth grade in the NGSS cross cutting concepts and the following disciplinary core ideas: 1) Life Sciences; 2) Earth and Space Sciences; 3) Physical Science; and 4) Engineering, Technology, and Applications of Science.

Life Science (six–eight): The learning progression builds from the individual organism in sixth grade, to its place in an ecosystem in seventh grade, to the development of these systems over time in eighth grade. In sixth grade, the focus is on the structure of cells and organisms including: body systems, growth and development, and the basis of sexual and asexual reproduction. More detailed DNA-level of understanding is deferred to eighth grade, after students have developed sufficient understanding of chemical processes and atomic level structure for these concepts to be meaningfully developed. The PEs at seventh grade require knowledge of the interdependence of organisms to each other and abiotic factors, as well as the cycling of matter and flow of energy that maintains ecosystems. These concepts are supported by the energy and matter concepts from sixth and seventh grade. In eighth grade, the critical ideas of variability and natural selection are introduced, and together with the ideas of deep time and the fossil record, form the basis for the relationship between the history of the earth and life on it. These topics require understanding of time scale and population distributions of traits that need eighth grade level mathematical sophistication.

Earth and Space Science (six–eight): The learning progression builds from the interaction of earth's systems in fifth grade to a deeper exploration of the hydrosphere and atmosphere in sixth grade. These two systems play very large roles in weather conditions and in regional and global climate. In seventh grade, the focus turns to the geosphere as students learn about changes to the earth's surface, plate movement, and the formation of earth materials. In eighth grade, the earth takes its place in the solar system and the universe as students get a much broader sense of time and space, including the more cosmic perspectives of the solar system, Milky Way galaxy, and a universe teeming with other galaxies.

Physical Science (six–eight): The learning progression builds on the knowledge of the particulate structure of matter from fifth grade to an understanding of energy in terms of the motions of particles of matter in sixth grade. Students investigate thermal energy and the transfer of energy. They are also introduced to a conceptual understanding of potential and kinetic energy with the full mathematical understanding of the concepts delayed until eighth grade. In seventh grade, the structure and property of matter and chemical reactions are studied. These build on and deepen ideas from kindergarten through grade five (K–5). In seventh grade, students can connect the chemical nature of the earth and life science concepts and begin to develop atomic and molecular level ideas about matter that are the base for eighth grade and high school science. Eighth grade provides opportunities to continue the study of: forces and interactions built in K–5, applications of structure and function concepts introduced in sixth grade, structure and properties of matter introduced in seventh grade to the context of space science introduced in eighth grade. In eighth grade, mathematical expressions, relationships of forces and interactions, kinetic and potential energy are introduced and students begin to build an understanding of these concepts that includes more quantitative aspects. Waves and electromagnetic interactions are also not introduced until eighth grade because of the mathematical representations required for describing and quantifying their properties.

Engineering (six–eight): There are four engineering PEs. They are arranged for each grade to maximize opportunities for students to engage in the engineering practices. These standards can be combined with any of the science disciplines to provide rich learning experiences for students.

In conclusion, the SEP placed PEs in this integrated progression at each grade level to support a logical flow of content and increasing complexity of concepts across grade levels (from fifth through eighth grade). This arrangement of the CA NGSS provides the opportunity for cohesive content integration within and across grade levels.