Introduction to Grades Six Through Eight

The California Next Generation Science Standards (CA NGSS) define two possible progressions for the middle grades: the Preferred Integrated Course Model (Integrated Model), which interweaves science disciplines in a developmentally appropriate progression; and the Discipline Specific Course Model, in which each grade level focuses in depth on a different science discipline.

The two models differ only in the sequence; every student is expected to meet each middle grades' performance expectation (PE) by the end of the grade. "Sequence" here refers to in which course (grade six, seven, or eight) a particular performance expectation is mastered; this framework makes no requirements about the order in which performance expectations are taught within a given year. The example course sequences in this framework describe possible storylines but are not the only way.

Table 5.1 compares disciplinary core ideas (DCIs) that are emphasized in the performance expectations required at each grade level in the two models. For both models, all eight science and engineering practices (SEPs) are developed and all seven crosscutting concepts (CCCs) are highlighted at all grade levels (although each lesson may focus on only one or two, and each year may emphasize a particular subset).

As districts consider the progression that works best for their resources and local context, they should be aware of the historical context, rationale for each model, and potential limitations of each. This chapter outlines some of those issues.

Historical Background

The CA NGSS are aligned to the nationally developed NGSS. This nationwide effort specified performance expectations for each year: kindergarten through grade five. However, in the middle grades, the performance expectations were presented for the entire grade span: grade six through grade eight. Because California adopts instructional materials for kindergarten through grade eight on a statewide basis, performance expectations had to be placed at specific grade levels—sixth, seventh, and eighth. Therefore, the State Superintendent of Public Instruction (SSPI) recommended that the State Board of Education (SBE) adopt specific placement of the performance expectations for the middle grades at each grade level.

The SSPI convened the Science Expert Panel comprised of kindergarten through grade twelve teachers, scientists, educators, business and industry representatives, and informal science educators. This panel evaluated a range of options for the appropriate organization and sequence of the performance expectations. The public provided feedback to the Science Expert Panel via three open forums and a webinar. The Science Expert Panel concluded that an integrated model for grades six through eight would be the most effective model for optimizing student learning of the CA NGSS; the panel subsequently reviewed the national model developed by Achieve (2010), and adapted it to better align with California's needs and recommended only the Integrated Course Model to the SBE. The full list of events that led to the adoption of the Preferred Integrated Course Model is described at the California Department of Education (CDE) Web site: http://www.cde.ca.gov/ci/sc/cf/ch5.asp#link1. On November 6, 2013, the SBE unanimously passed the following motion: "To adopt the CDE staff recommendation that the SBE adopt the proposed integrated model as the preferred model for middle grades (6, 7, and 8) science instruction, and requested that the CDE reconvene the Science Expert Panel to develop as an alternative model a discipline specific model based upon the domain specific model outlined by Achieve in the NGSS appendix K." In December 2014, the Science Expert Panel reconvened to develop the Discipline Specific Model of the CA NGSS.

The board's intent in their November 2013 action was to establish one integrated model in California for grades six through eight that was preferred by both the SSPI and the SBE and one discipline specific model as an alternative.

Table 5.1. Comparison of When DCIs are Primarily Addressed in the Two Middle Grades Models

blank	DISCIPLINARY CORE IDEA	SUBTOPIC	Preferred Integrated			Discipline Specific		
			6	7	8	6	7	8
EARTH AND SPACE SCIENCE	Earth's Place in the Universe	Universe, Stars, Solar System			x	x		
EARTH AND SPACE SCIENCE	Earth's Place in the Universe	History of Planet Earth			x	x		
EARTH AND SPACE SCIENCE	Earth's Systems	Water Cycle, Weather, Climate	x			x		
EARTH AND SPACE SCIENCE	Earth's Systems	Rock Cycle, Plate Tectonics		x		x		
EARTH AND SPACE SCIENCE	Earth and Human Activity	Global Climate Change Causes	x			x		
EARTH AND SPACE SCIENCE	Earth and Human Activity	Resources Availability		x		x		
EARTH AND SPACE SCIENCE	Earth and Human Activity	Natural Hazards		x		x		
EARTH AND SPACE SCIENCE	Earth and Human Activity	Resource Consumption			x	x		
LIFE SCIENCE	From Molecules to Organisms: Structures and Processes	Cells & Body Systems	x				x	
LIFE SCIENCE	From Molecules to Organisms: Structures and Processes	Photosynthesis and Respiration		x			x	
LIFE SCIENCE	Ecosystems: Interactions, Energy, and Dynamics			x			x	
LIFE SCIENCE	Heredity: Inheritance and Variation of Traits	Sexual Versus Asexual Reproduction	x				x	
LIFE SCIENCE	Heredity: Inheritance and Variation of Traits	Mutations			x		x	
LIFE SCIENCE	Biological Evolution: Unity and Diversity				x		x	
PHYSICAL SCIENCE	Matter and its Interactions	Atoms, Molecules, States of Matter		x				x
PHYSICAL SCIENCE	Matter and its Interactions	Chemical Reactions		x				x
PHYSICAL SCIENCE	Motion and Stability: Forces and Interactions				x			x
PHYSICAL SCIENCE	blank	Kinetic Energy and Collisions	x		x			x
PHYSICAL SCIENCE	blank	Heat and Heat Flow	x					x
PHYSICAL SCIENCE	blank	Potential Energies & Gravity			x			x
PHYSICAL SCIENCE	Waves and Their Applications in Technologies for Information Transfer				x			x
ETS	Every course includes integrations with ETS		x	x	x	x	x	x
SEP	Every course utilizes all eight SEPs		x	x	x	x	x	x
CCC	Every course highlights all seven CCCs		x	x	x	x	x	x

Learning from Other Successful Countries

The Science Expert Panel preferred the Integrated Model based in part on evidence from other countries and provinces. Analyzing the science standards of ten countries that produce significant scientific innovations and produce high scores on international benchmark tests, Achieve (2010) found that all ten of these countries use an integrated science model through the middle grades, and seven of the ten countries keep science integrated all the way through grade ten. Summarizing qualitative trends from their analysis, Achieve (2010) concluded, "Standards based around 'unifying ideas' for Primary through Lower Secondary seem to confer more benefits than a discipline-based structure." This statement articulates part of the rationale behind the seven crosscutting concepts from the CA NGSS that link together all disciplines of science and engineering. Because these CCCs cannot be explained within a single context or even a single scientific discipline, the SBE adopted the Integrated Model as the preferred model.

Matching University Training with Middle Grades Teaching

Many science teachers receive a university degree in a specific discipline of science within a specific university department (e.g., biology, chemistry, physics, geology), so they are expected to have stronger content knowledge in that field. Linda Darling-Hammond summarized the research on the weak but measurable link between a teacher's subject matter knowledge and student achievement by saying that "the findings are not as strong and consistent as one might suppose … [perhaps] because subject matter knowledge is a positive influence up to some level of basic competence in the subject but is less important thereafter" (Darling-Hammond 2000). Teachers with a general science certification teaching the middle grades exceed that basic level of competence in all sciences and should be able to teach effectively in both models. Perhaps more important than university learning within a discipline is the pedagogical content knowledge (PCK) learned from years of experience teaching a specific subject area. Some of this PCK is discipline specific (such as awareness of specific preconceptions within one's discipline) (Sadler et. al. 2013), but much of it relates to SEPs and CCCs that span all disciplines of science and will transfer fluidly from one course model to the other. It was the judgment of the Science Expert Panel that teachers will remain highly qualified to teach in both the Integrated and Discipline Specific Models.

Sequencing in a Developmentally Based Learning Progression

The CA NGSS are intentionally designed so that students slowly build up knowledge and skills in all three dimensions, addressing more sophisticated challenges or revisiting simple ones at a deeper level as they progress through the grades. Achieve also noted that even in exemplary standards, most countries paid insufficient attention to developmental learning progressions. They suggest, "Developers of new standards will need to tease out the prerequisite knowledge and skills, to provide a conceptual basis for understanding" (Achieve 2010). Appendix E of the CA NGSS spells out the developmental progression of ideas within each domain, but there is also prerequisite knowledge from one domain that is applied in a separate domain within the CA NGSS. For example, it is difficult to fully understand photosynthesis, respiration, and how matter is rearranged as organisms consume other organisms without a firm understanding of atoms, molecules, and chemical reactions. In the Discipline Specific Model, the life science DCIs appear in grade seven, but core ideas about the nature of matter are not introduced until grade eight. The Integrated Model was arranged with this sequencing in mind, and the prerequisite knowledge is often placed within the same course so that it can be taught alongside the application. Successful implementation of the Discipline Specific Model will require some remediation of the missing prerequisite knowledge, and the specific courses in this framework identify when these situations occur in each course.

Introduction to the Preferred Integrated Course Model for Grades Six through Eight

The Preferred Integrated Course Model (Integrated Model) provides a unique opportunity for teachers to truly address real-world phenomena, ask questions, and seek answers to those questions without regard to disciplinary boundaries. In reality, all objects obey the laws of physics, are made of chemical matter, interact with other parts of the Earth and space system, and are ultimately observed by us as living beings. Many professional scientists do have disciplinary specializations, but more and more of these barriers are being broken by interdisciplinary research.

The Integrated Model also supports the CA NGSS vision of a strong developmental progression where students spiral through the curriculum, revisiting ideas in increasing complexity and detail. Complex scientific problems exist within all the domains of science and engineering, and the Integrated Model places the most complex phenomena at the end of the grade span when students are most ready to face them. Students undergo considerable growth from grades six through eight; it makes the most sense to capitalize on their growth.

Integration was built directly into the architecture of the CA NGSS with the dimension of crosscutting concepts (CCCs). These ideas provide a common thread to all domains. Deep understanding of the CCCs (along with the science and engineering practices or SEPs) provides a firm foundation for students to pursue future science in any discipline. This course emphasizes the CCCs, including a strong focus on **systems [CCC-4]** at the beginning of grade six and culminating with **stability and change [CCC-7]** by the end of grade eight (with all the other CCCs embedded along the way). This course is designed to be an integrated course, as opposed to a coordinated science course (table 5.2): "Simply stated, the difference between coordinated and integrated is the type of connections that can be made between and among the various fields of science" (Sherriff 2015). Coordinated science delivers the different domains of science in succession, while a true integration both introduces and teaches related content to answer a single question about a phenomenon within science.

Table 5.2. Integrated Versus Coordinated Science

INTEGRATED	COORDINATED
Every science every year.	Every science every year.
Performance expectations are bundled according to natural connections between them and enable learning about the connections in addition to what is discipline specific.	Performance expectations are bundled according to discipline, resulting in learning that is mostly discipline specific.
Connections between science disciplines are clearly made for and by students.	Connections have to be "remembered" by the student and the teacher.
Examples outside of a particular discipline are given when appropriate.	Examples within a particular discipline are normally given.
A few examples: • Astronomy is taught in conjunction with gravity and forces. The connections and applications of physics are applied to astronomy. • Heat (physics) is taught at the same time, using climate and weather as the applied examples. • Light and the chemistry of photosynthesis are all taught in an interconnected presentation.	A few examples: • Astronomy is taught conceptually with gravity and forces taught in separate units that may not connect to astronomy. • Heat is taught as a separate physics unit. Climate and weather are taught as a separate unit. • Light is taught as a separate unit as strictly physics with no connections to life science needed.

Source: Sherriff 2015

Purpose and Limitations of this Example Course

The CA NGSS do not specify which phenomena to explore or the order to address topics because phenomena need to be relevant to the students that live in each community and should flow in an authentic manner. This chapter illustrates one possible set of phenomena that will help students achieve the CA NGSS performance expectations (PEs). The phenomena chosen for this statewide document will not be ideal for every classroom in a state as large and diverse as California. Teachers are therefore encouraged to select phenomena that will engage their students and use this chapter's examples as inspiration for designing their own instructional sequence.

In this chapter's examples, each year is divided into instructional segments (IS) centered on questions about observations of a specific phenomenon. Different phenomena require different amounts of investigation to explore and understand, so each instructional segment should take a different fraction of the school year. As students achieve the performance expectations within each instructional segment, they uncover **disciplinary core ideas (DCIs)** from the different fields of science (physical science, life science, and Earth and space science) and engineering. Students engage in multiple practices in each instructional segment, not only those explicitly indicated in the performance expectations. Students also focus on one or two CCCs as tools to make sense of their observations and investigations; the CCCs are recurring themes in all disciplines of science and engineering and help tie these seemingly disparate fields together. The SEPs, DCIs, and CCCs grow in sophistication and complexity throughout the K–12 sequence. While this chapter calls out examples of the three dimensions in the text using color-coding, each element should be interpreted with this grade-appropriate complexity in mind (appendix 1 of this framework clarifies the expectations at each grade span in the developmental progression). Engineering, technology, and application of science (ETS1) are a fundamental part of each course. As students explore their environment during this grade span, they develop their growing understanding of the interconnections and interdependence of Earth's natural systems and human social systems as outlined in California's Environmental Principles and Concepts (EP&Cs). All three of the CA NGSS dimensions and the EP&Cs will prepare students to make decisions about California's future and become sources of innovative solutions to the problems the state may face in the future.

Essential Shifts in the CA NGSS

The 1998 *Science Content Standards for California Public Schools: Kindergarten Through Grade Twelve* (1998 CA Science Standards) were written at a low cognitive level ("Students know … "), with some attention paid to the process of science as a separate set of Investigation and Inquiry standards. In the CA NGSS, every performance expectation is "three-dimensional," meaning that it requires proficiency in SEPs alongside a deep understanding of DCIs and the ability to relate these ideas to CCCs that are common across the domains. As a result, instructional materials and strategies must shift.

Some have described the CA NGSS as having more depth and less breadth, but that may not be a precise description. In many of the instructional segments of these middle grades courses, students may be expected to know *fewer* details about phenomena than they did in the 1998 CA Science Standards, with the focus shifted to richer reasoning and more opportunities to apply knowledge. These details are not missing from the CA NGSS, but they have been moved from the middle grades to high school, where they are more developmentally appropriate. The level of detail builds slowly. Teachers often complain that students do not remember concepts from year to year, but perhaps this forgetting is a consequence of teachers' desire to provide self-contained instructional segments that answer all the questions raised by the time of the test, just like a 30-minute episode of a sitcom on television. The CA NGSS is more like a long-running drama series with a number of interweaved storylines that develop over years. In order to accomplish this slow build up, teachers likely will have to make major modifications to some of their favorite lessons or even leave them behind because those lessons focus on providing all the "answers," situations in which students memorize the details and jargon that represent the current state of understanding of science by scientists. The time they used to spend on those parts of the lessons will instead be invested in asking students to apply their mental **models [SEP-2]** of the physical world, like scientists grappling with new situations, and to talk like scientists not by using scientific words but by being able to provide **evidence [SEP-7]** to support their claims. Districts and schools will need to invest in significant resources for professional learning to help teachers make these modifications in supportive, collaborative environments.

Grade Six Preferred Integrated Course Model

This section is meant to be a guide for educators on how to approach the teaching of the California Next Generation Science Standards (CA NGSS) in grade six according to the Integrated Model (see the introduction to this chapter for further details regarding different models for grades six, seven, and eight). It is not meant to be an exhaustive list of what can be taught or how it should be taught.

A primary goal of this section is to provide an example of how to bundle the performance expectations into integrated groups that can effectively guide instruction in four sequential instructional segments. There is no prescription regarding the relative amount of time to be spent on each instructional segment. As shown in figure 5.1, the overarching guiding concept for the entire year is "Systems within organisms and between them are adapted to Earth's climate systems."