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Science Curriculum Development with Next Generation Standards: Meeting the Needs of In-Service Teachers

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Science Curriculum Development with Next Generation Standards:
Meeting the Needs of In-Service Teachers

By: Laura Arnow

A thesis submitted in partial fulfillment of the requirements for the

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School of Education

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Science Curriculum Development with Next Generation Standards:
Meeting the Needs of In-Service Teachers

By: Laura Arnow

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Science Curriculum Development with Next Generation Standards:

Meeting the Needs of In-Service Teachers

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Abstract

The Next Generation Science Standards (NGSS) bring new opportunities to American classrooms, with their emphasis on investigation, reliance on data, and constructing explanations and lines of argument based on evidence. However, they also pose considerable challenges both to teachers and students. Years of minimal science instruction during the era of No Child Left Behind (NCLB) have left a generation of students unfamiliar with the idea of questioning, and a professional cohort of teachers with little experience with inquiry curriculum or confidence in their mastery of science content. This leaves a gap for curriculum design. This study assessed the needs of a small rural school district's teachers as the district moves toward implementation of NGSS in grades K-12. Based on the needs assessment, I developed (a) a set of model lessons integrating the NGSS with state Environmental Education standards as well as interdisciplinary connections such as science applications of mathematics and arts, and (b) a plan for professional development to build capacity in curriculum design and implementation for inquiry science, in the context of a school garden.

Keywords: Next Generation Science Standards, professional development, constructivism, school gardens, Science and Engineering Practices, inter-disciplinary, curriculum.

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Chapter One: Introduction

The Next Generation Science Standards, or NGSS (National Research Council, 2013) combine eight scientific practices with seven crosscutting concepts and numerous disciplinary core ideas within the physical, life, and earth sciences and in engineering. The design of the standards is intended to help students develop the skills and thinking habits of scientists as they construct knowledge through experience. The standards demand of teachers a high level of professional skill and content knowledge in order to design lessons that effectively create opportunities to construct accurate scientific understanding from direct observations (Bybee, 2014). These learning opportunities must help students both understand content at increasing levels of complexity and develop the practices of scientists and engineers at increasing levels of skill. Content and practice must be blended within the learning environment, since the two are synergistic in the learning brain. According to Krajcik, Codere, Dahsah, Bayer and Munf (2014), “if we want students to learn the content, they have to engage in the practice. But if we want students to learn the science and engineering practice, then they have to engage in content. Leave one out, and students will not develop proficiency in the other” (p.159). This project seeks to improve teacher capacity to integrate the instruction of content with science and engineering practices. I have developed a model unit composed of five lessons for NGSS-aligned science instruction that will be presented in a professional development workshop for K-8 in-service teachers in a small rural school district in central California, and have created a draft NGSS implementation plan for the district.

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Statement of the Problem

The years of implementation of the No Child Left Behind Act of 2001 (No Child Left Behind [NCLB], 2002) created schools so focused on improving test scores in Language Arts and Mathematics that the amount of time and focus for science shrank to almost nothing. Professional development for teachers in science, especially in elementary science, was largely abandoned in favor of literacy training. Discovery learning (the process of students constructing meaning through experience) was discouraged while direct instruction (the process of teachers presenting structured and sequenced information to students) was encouraged (Marzano, 2013). As a result most elementary teachers now have less skill and content understanding for teaching science with inquiry than before NCLB, and their confidence in their ability to instruct effectively in the sciences is low (Bell, Bicker, Tzou, Lee & Van Horne, 2012). As the new standards are introduced and begin to be implemented over the course of the next three to five years, elementary teachers will need a new set of skills for designing and delivering effective science curriculum to meet these new standards and to emphasize their three dimensions: Disciplinary Core Ideas (content), Science and Engineering Practices (the habits and abilities of scientists), and Cross-Cutting Concepts (the conceptual structures that span all disciplines of science) (National Research Council, 2013). Teachers will need confidence in their own skills and understanding in the science content they teach. Perhaps most importantly, they will need an attitude of excitement and the disposition to jump into exploration along with their students (Bybee, 2014).

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Purpose of the Study

The purpose of this study was to introduce teachers in the district to the NGSS, in part through a set of model lessons built with the NGSS in the elementary grades. The lessons highlight three out of the eight Scientific and Engineering Practices: #4 Analyzing and interpreting data, #6 Constructing explanations and designing solutions, and #7 Engaging in argument from evidence (National Research Council, 2013). In developing these lessons, I constructed a frame or template that teachers can use in the future to create their own lesson sequences which similarly fit with the NGSS. These lessons were set in a school garden in order to investigate and incorporate available curriculum such as the California Environmental Education Initiative (California Department of Resources Recycling and Recovery, 2015), Project WET (Project WET Foundation, 2015), and LifeLab's The Growing Classroom (Jaffe & Appel, 2007) along with NGSS. The lessons will be piloted in a prototype professional development session for K-8 teachers during the summer to enable teachers to plan their first NGSS-based science investigations for the upcoming school year.

The lessons are based on models of effective science instruction similar to Problem Based Instruction (PBI), which poses open-ended questions or challenges for students to solve, placing the teacher in the role of facilitator or coach rather than lecturer or expert (Torp and Sage, 2002). They incorporate the “5 Es” model of investigation, a scaffold for inquiry lessons developed by Biological Sciences Curriculum Study beginning in 1987 (Bybee, 2013). The 5Es model was field-tested as more effective than a “common-place” text and lecture-based model in research by Wilson, Taylor, Kowalski and Carlson (2010). The sequence of five lessons focus on a single Performance Expectation from the NGSS, and include lessons that provide opportunities

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to use the three targeted Science and Engineering Practices. In addition, the lessons each incorporate a strategy teachers can implement to help students develop in the Practices as well as the related Disciplinary Content Ideas and Cross-Cutting Principles, such as a science talk, sketching from nature, and analyzing data.

Research Questions

The research was framed around on the following questions:

1. What are the key needs of elementary science teachers making the shift toward the Next Generation Science Standards?
2. How can a district support teachers in moving toward Next Generation Science Standards implementation?
3. How can school gardens and habitat sites help science teachers meet Next Generation Science Standards?

Theoretical Model

Active learning is important in effective acquisition of content learning. Bruner (1964) outlined the process by which children create meaning in the world through action (enactive), image (iconic), and language (symbolic) representations. He defined this process as discovery learning. His interactionist theory of learning emphasizes the relationship between experience and representation, including linguistic representation, as children simultaneously develop understanding about how the world works and skill at communication. This is closely aligned with the design of the NGSS Practices, which emphasize gathering data through observation and exploration, as well as through text-based research, as the foundation of students' conclusions about their experience. Piaget's theory (1964) of cognitive development in children delineates

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the ways children observe and engage with the physical world and come to understand relationships between physical objects and (later) with their representations in image and language. These theories were influential in the development of experiential science curriculum in the late 1960s and early 1970s (Education Development Center, 1970), although much of this type of instruction disappeared during the later part of the twentieth century under pressure from legislative mandates to increase instruction in math and language arts (Bell et al, 2012).

The advent of the Common Core State Standards (National Governors Association, 2010) and Next Generation Science Standards (National Research Council, 2013) has brought into sharp focus the needs of elementary students as they approach more intensive, process-oriented learning within content areas. For example, the focus on academic discourse within the CCSS and NGSS demands that students use collaborative, peer-friendly language as they construct meaning, as well as the more formal register of the academic exchange of ideas, all based on evidence drawn from text and experience. The emphasis on technology and engineering inherent in the Next Generation Science Standards requires instructional design with a strong hands-on, collaborative component.

School gardens, with their opportunities for hands-on learning, observation over time, and cooperative projects, provide unique instructional environments for collaborative investigation. The planned teacher workshop features school garden-based lessons as one type of experiential science learning particularly well suited to the integration of science, technology, engineering, art, and math. For the workshop, I've developed demonstration lessons for teachers to explore NGSS based instruction within the garden environment.

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Researcher Background

I have taught in a variety of situations, with students from primary grades through middle school and in situations ranging from formal urban classrooms to gardens in agricultural communities to dirt-floor schools in the southeast Asian rainforest to the decks of tall ships under sail. I am impassioned about helping students recognize their own ability to understand the world around them by trusting their own observations and logical conclusions. The district where I currently teach is fortunate to have a school garden at each site, though they are largely underutilized at present, and to have leadership at the district level concerned about science education.

In this community, although a few parents are college-educated, most of the caregivers have a high school education or less. The student body has a widespread apathy about learning in general, and about math and science learning in specific. One of the elementary schools has worked for many years to rise out of Program Improvement status, and students spend much of their time working in prescribed remedial math and language arts programs. These challenges have made it difficult for many teachers to develop and implement engaging science curriculum.

By structuring hands-on experiences for teachers to experiment with NGSS, I hope to open a window to inquiry science at these schools. I hope that by working first with colleagues and then with students on model lessons, teachers will develop the confidence to step out along with their students into the world of exploration and discovery--the world of the real scientist.

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Definitions

Collaborative learning. An instructional model that focuses on interaction, with students working in groups to solve problems or answer questions, and the teacher functioning as a coach and designer of scenarios of interest to students.

Experiential learning. An instructional model in which students acquire knowledge by reflecting on experience, such as conducting an experiment and inferring the causes of physical phenomena.

Framework. The National Research Council (NRC) of the National Academy of Sciences managed the first of two steps in the creation of the *Next Generation Science Standards* by developing the A Framework for K-12 Science Education, which was released July 2011.

Inquiry learning. Learning based on students' investigations of questions and development of solutions to problems. Inquiry is focused on the process of discovery rather than on the absorption of information.

The following terms are the key components of the Next Generation Science Standards (National Research Council (NRC), 2013).

Performance Expectation. Performance expectations are what students should know and be able to do in science. These can be assessed in different ways. The NGSS defines them with clarification statements and assessment boundaries, both of which help delineate the different expectations from one grade band to the next.

Scientific and Engineering Practices (Dimension 1). These are the actions and habits of mind used by scientists and engineers as they work to understand the world around us and to

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solve problems faced by people. Practices are considered a combination of skills and knowledge needed for science and engineering. These practices help define “inquiry” as a blend of cognitive, social, and physical activities.

Cross Cutting Concept (Dimension 2). Crosscutting concepts exist in all three domains of science and in engineering, and help connect them. They include: Patterns, similarity, and diversity; Cause and effect; Scale, proportion and quantity; Systems and system models; Energy and matter; Structure and function; Stability and change. By making them explicit for students, teachers can help students organize their thinking about science as an interrelated whole.

Disciplinary Core Idea (Dimension 3). Disciplinary ideas are grouped in four domains: the physical sciences; the life sciences; the earth and space sciences; and engineering, technology and applications of science. These ideas are significant across several disciplines or are key within one, provide important tools for more complex understanding, help students connect their own interests to science and its impact on society, and are relevant with increasing complexity as students grow older.

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Chapter Two: Literature Review

Introduction

Science instruction in American schools is on the brink of a major shift, as new national standards, the Next Generation Science Standards (NGSS) are introduced in many states. The NGSS represent the culmination of decades of discussion, design, and development (Bybee, 2014), and seek to pair scientific practice with content--helping students develop not only the knowledge of scientific phenomena, but also the skills and habits of mind of scientists and engineers. This shift will challenge teachers who are emerging from decades of intense focus on literacy instruction and minimal emphasis on science instruction to create learning experiences grounded in data, evidence, and scholarly argument.

Learning Science in Elementary Schools

Historically, science education has shifted in cycles from experiential to text-based and back again. From the apprenticeship model of the Age of Enlightenment to the memorization of laws in Industrial Age classrooms, science teachers and learners have followed the ebb and flow of popular thinking about the most important science ideas and the most effective ways to transmit them. Dewey (1916) decried the tendency to force students to learn science as a fully formed subject instead of letting them experience scientific phenomena in the material world around them. But by 1940, teachers complained that most of their colleagues had resorted to instruction from textbooks alone (Gemmill, 1949). Unfortunately, students educated in an environment of text-based science learning grew up reluctant or ill-equipped to become hands-on teachers, and as a result a generation of teachers in the 1950s taught mainly from textbooks.

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The space race and the open classroom. As World War II gave way to the Cold War, international competition for technological superiority led to pressure for change in American science classrooms from universities down to kindergartens. Simultaneously, the work of Jean Piaget (1964), examining the psychological development of the young learner, began to reach the United States. These two trends led to the federally funded Elementary Science Study (ESS), a project that sought to bring developmental psychology into an open classroom model to facilitate independent, exploratory learning (Barth, 1972). The ESS curriculum featured teacher guides full of suggestions rather than instructions, classrooms full of ordinary materials rather than of textbooks, and children and teachers full of questions rather than answers. The goal was for children to arrive at intelligence through shared explorations and conversations, out of a belief “that, by opening up to children the many fascinating aspects of the ordinary world and by enabling them to feel that their ideas are worthwhile having and following through, their tendency to have wonderful ideas can be affected in significant ways” (Duckworth, 2006, p. 12).

ESS documented and assessed its own work by collecting samples of student discourse and writing, some of which can be found in its published teacher guides. Duckworth, a leader in the project, believed that conversation with peers and thoughtful interviews of students by teachers were key in the development of sound, evidence-based scientific thinking in young children. The developers found that students in the ESS program who had been described as “non-verbal or otherwise unsuccessful in their day to day schoolwork” became more successful in reading and generally in the tasks of school (Lockard, 1968). However, it is not clear whether the “non-verbal” students were English learners or if some other factor was contributing to their limited language skill. These results, like the developers’ impressions that children were

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generally more engaged, purposeful, motivated, and able solve problems, were based on classroom observations as well as surveys and interviews of teachers (Lockard, 1968).

ESS' National Science Foundation funding ended in 1973, after the group had developed and tested 80 science curriculum units in 13 years. Its work became the foundation of other efforts to promote inquiry-based science and mathematics, including the Unified Science and Math for Elementary Schools (Lomon, 1975), which proved powerful at helping students increase math skill and problem-solving ability, though less effective at increasing science understanding (Shann, 1977).

Beginning in 1988, with National Science Foundation funding, the University of California at Berkeley's Lawrence Hall of Science used the ESS modules, among other sources, to create FOSS Science, a kit-based science curriculum with inquiry as a major method of instruction. Unlike the ESS units, FOSS units included specific instructions for student activities, with prompting questions for teachers to use in guiding discussion. Later revisions of the program included enhancements to support English learners, including vocabulary lists for pre-teaching and supporting texts with strong visual components (Full Option Science System, 2013). FOSS encourages classroom discourse through structured discussions after activities, and provides strategies for teachers to support small groups working together with materials. Students also write, graph, and draw their findings on worksheets, and the texts provide reading experiences to enhance the science/literacy connection. By repeatedly revising the program to meet the demands of multiple state standards, FOSS has been able to penetrate the science market in almost every state, though adoption remains much lower than more traditional text-based programs (FOSS, 2013). The Third Edition of FOSS science was designed with the

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National Science and Engineering Standards (NSES) Frameworks (NRC, 1996), so it includes the Science and Engineering Practices and Cross-cutting Principles, but does not claim to match with all three dimensions and the Performance Expectations of NGSS yet.

Return to text-based science. The passage of the No Child Left Behind Act in 2001 brought changes that reversed or inhibited efforts to provide inquiry science and its related language development in elementary schools. Teachers faced with a legislated obligation to increase test scores in reading and math found less and less time for science. Elementary science was reduced to a minimum or eliminated altogether in some classes, schools and districts (Griffith & Scharmann, 2008). Some educators came to rely on adopted literacy programs or packaged English language development curricula to provide nonfiction science text lessons within a basal reader, or science facts within English lessons. These materials were seen as a replacement for dedicated science instruction. The pendulum was swinging back in the direction of text-based science instruction.

Learning Science with National Standards

Even in the face of the move toward a legislated focus on literacy and math, forward-thinking science educators were working on designing science curriculum framed around the practices and thinking habits of working scientists. Between 1991 and 1995 teachers and scientists worked together to develop the National Science Education Standards (NRC, 1996), a document which outlined inquiry science education as a process of developing content understand alongside scientific competency (Olson & Loucks-Horsley, 2000). Over the next 15 years, this model formed the basis of new standards now being adopted and implemented by states. The Next Generation Science Standards (NRC, 2013) call for students to use experience

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and evidence throughout their science education, beginning in kindergarten with using and sharing observations, constructing arguments supported by evidence, asking questions to obtain information, and communicating solutions. By third grade students are also expected to define a problem, make a claim, compare multiple solutions to a problem, analyze data, and plan and carry out an investigation. These are not the type of applications that can be undertaken with basic language arts skills like grammar and vocabulary alone. Students need the tools of discourse: the give and take of argumentation, the cause-and-effect language that links observation with hypothesis, the transformation of inherent curiosity into well-framed questions that will yield needed information, the mathematical fluency that turns raw numbers into analyzed data (NRC, 2013).

Classroom conversations in science. Teachers will need new strategies and skills to help students meet the demands of the Next Generation Science Standards. The integration of science instruction with math and language arts, particularly for English learners, has been found to be highly dependent on teacher skill and confidence in both science and ELD, as well as in appropriate strategies for successful integration of language and content (Stoddart, T., M. Latzke, & D. Canaday, 2002). Zwiers, O'Hara, and Pritchard (2014, in press) suggest that students need support in the art of constructive conversation, and that teachers can learn to model and scaffold academic discourse in order to help students hone their skills at creating, clarifying, fortifying and negotiating ideas in content areas.

Data analysis in science. In addition, teachers need skill at helping students work with and analyze data, particularly data displayed graphically. This implies explicit instruction and experience with the graph-related skills of translation (shifting information from one form, such

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as a table, into another, such as a graph), interpretation (making sense of graphically displayed data in relation to real-world situations), and elaboration (carrying the information displayed into a graph beyond the data into implications, predictions, or hypotheses) (Friel, Curcio & Bright, 2001). Tools such as the I² (Identify and Interpret) model can help teachers to frame data analysis activities within science explorations (Biological Sciences Curriculum Study, 2012).

Science journals. The new national standards may create a new opportunity, beyond legislated approaches to the language instruction of classrooms, and beyond teacher-centered, text-based science instruction. These standards may help give rise to elementary classrooms where science learning is a matter of creating ideas based on experience, and where language learning is a matter of acquiring the tools for communicating about the “wonderful ideas” described by Duckworth (2006). Several tools may be important in this work. Science notebooks or journals can help students solidify their understanding, work with academic language, and demonstrate the effectiveness of instruction (Klentschy, 2008; Aschbacher & Alonzo, 2006). This type of writing may be effective both in the traditional classroom and in non-traditional settings. Furthermore, journals enhanced with sketches offer a way for students to synthesize, record, and share their content learning even when language or literacy skill might otherwise pose a limitation. (Bedward, Carter, Madden, Minogue, & Wiebe, 2010). Art activities such as sketching from nature (Laws, Breunig, Lygren, & Lopez, 2012) are widely believed to activate different regions of the brain, engage students with the natural appeal of art, and enhance observational skill, though it is difficult to find studies that rigorously demonstrate academic benefits of arts integrated with science (Baker, 2013). As promising as these tools are, teachers

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need support in understanding them and incorporating them into lessons and units that meet the Next Generation Standards.

School gardens and habitats. Often, the most engaging experiences, and those most likely to generate lively and meaningful language opportunities as well as conceptual connections and increased understanding, are those outside the boundaries of the traditional teacher-centered classroom. Within the classroom, the ESS developers capitalized on the natural curiosity of young children to extend their understanding of science (Barth, 1972; Duckworth, 2006). The Understanding Language project at Stanford (Lee et al, 2013) seeks to spring from that science excitement into the realm of high level academic discourse within the classroom. However, non-traditional learning settings such as the natural science lab of a school garden may yield new opportunities for young science students to extend and content and practice learning. School gardens around the world provide an intriguing location for learning about the natural world, as well as a comfortable, multicultural environment where children unselfconsciously practice academic English language as they explore the garden ecosystem along with cultural practices related to agriculture and horticulture (Cutter-Mackenzie, 2009, Waters, 2008).

Environmental education organizations are working closely with leaders in the movement for national science standards (Whitacre, 2014). The Environmental Education Foundation notes that environmental education is particularly well suited to developing the Science and Engineering Practices in NGSS (National Environmental Education Foundation, 2015). To date, however, little research exists on effective ways to help teachers use school gardens to enhance science skill and understanding with the Next Generation Science Standards. For this reason, this project seeks to develop a plan for professional development using school gardens as a platform.

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Summary

Science education has swung from experiential to text-based instruction over the course of the history of public education in the United States. As American teachers move from the recent focus on direct instruction in literacy and math into a new set of standards demanding inquiry-based, evidence-centered student exploration of scientific concepts and practices, teachers will need a new set of skills and conceptual understandings.

Using a small school district as a sample, this project investigated the type of support K-8 teachers need in order to move with confidence and skill into teaching science using the Next Generation Science Standards. Based on a survey of teachers' needs, I developed a proposed timeline to move elementary educators through awareness and transition toward NGSS implementation in a small district. I also developed a demonstration lesson sequence to serve as a model for teachers to explore the structure of NGSS and strategies to teach NGSS based science in elementary grades using the school garden. In this way, the project will begin to find ways to help students and teachers step together into the world of exploring, developing and sharing "wonderful ideas."

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Chapter Three: Methodology

Introduction

This project investigated the need for professional development as teachers develop the skill of integrating science and engineering practices with disciplinary content in K-8 instruction. Based on a survey of K-8 teachers in a small rural district, I created a needs assessment and an outline for district support of the implementation of Next Generation Science Standards over the next four years. In addition, I developed a model set of demonstration lessons to highlight the 5E model (Bybee, 2013), an instructional model teachers can use in their own classrooms for independently designing and implementing science learning experiences incorporating the three dimension of the NGSS. This product is the framework for a professional development workshop giving teachers an experience with a lesson progression toward a NGSS performance expectation. The workshop plan emphasizes several key Scientific and Engineering Practices and several tools teachers can use in their classrooms.

This project seeks to answer the following questions:

1. What are the key needs of elementary science teachers making the shift toward the Next Generation Science Standards?
2. How can a district support teachers in moving toward Next Generation Science Standards implementation?
3. How can school gardens and habitat sites help science teachers meet Next Generation Science Standards?

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Product Design

Description. This project created a set of demonstration lessons for teacher professional development in K-8 science, highlighting the performance expectations, three dimensions, and cross-curricular connections of the Next Generation Science Standards in the environmental setting of a school garden.

Justification. Board and district concerns, and informal contact with teachers in the subject district, all indicate that the professional community in this district is generally unaware of the Next Generation Science Standards and the new ways of teaching and learning they represent. The best way to learn how to do something new is to try it—and learning a new way of teaching is no different. As a result, I decided to construct a professional development plan, including an introductory day in which teachers will conduct and analyze an inquiry sequence. This workshop will give teachers a chance to conduct a science investigation and engineering challenge while simultaneously observing and analyzing the activities as teachers. By nesting a hands-on investigation within the teacher workshop, the event gives teachers a chance to explore the shifts in science education from both the teacher and the learner perspective.

This district, like many others in California, supported the construction of school gardens at each of its sites, but these gardens are not well integrated into the academic curriculum at the K-8 schools. District leadership and some teachers expressed a desire to revitalize the gardens and reintegrate them into the daily life of the schools. School gardens are a valuable and underutilized resource in this district and elsewhere for integrating curriculum and motivating students to participate in inquiry science, and for this reason the workshop will be conducted in a

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school garden setting. In addition to these reasons, this product is under development at the request of the Board of Directors and Superintendent of the District.

Framework

Description. The workshop is based on the Next Generation Science Standards (NRC, 2013) and also refers to the California Environmental Education Initiative's Concepts and Practices (California Department of Resources Recycling and Recovery, 2015), and the North American Environmental Education Association's Guidelines for Learning (Simmons, 2010). The Common Core State Standards (National Governors Association, 2010) are referenced within the Next Generation Science Standards. The implementation plan is based on local needs in combination with the California Department of Education's draft timeline for NGSS implementation as published by the California Science Teachers Association (CSTA, 2015).

Justification. These two sets of standards are leading the way for science education across the United States. The state of California is just beginning to develop an Environmental Literacy Plan, as outlined by the North American Environmental Education Association (Simmons, 2010). However, the state has a set of Environmental Concepts and Principles and a K-12 curriculum available for download or free distribution with attendance at a workshop, and is one of 13 states in the process of implementing the NGSS (National Academy of Sciences, 2015). Although this small district will not likely be at full implementation of either the EEI standards or the NGSS in the next few school years, introducing the standards and providing planning resources for teachers will enable professional collaboration teams to begin the process of integrating these new standards into their unit design over the next few years.

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Setting

The setting of this project is a K-12 school district. Its two K-8 schools serve a total of about 800 students in a rural area inland from the central California coast. Each school is set in a small town of fewer than 2,000 people, and many students live in the rural areas surrounding the towns. A small high school serves both communities. The closest small cities are within 10 miles of each school, and the major metropolitan Bay Area is about a 45 minute drive. Many families work in agriculture, with a small number serving as migrant farmworkers.

The two K-8 schools are Title I schools, with 61% of students at one school and 80% at the other participating in the free and reduced lunch program. About half the students are English Language learners, and one of the schools has a Dual Immersion program for just under half of the K-5 students, enrolling both native Spanish and native English speakers. All three schools have school gardens, technology labs, libraries, and well-maintained campuses with athletic facilities and recreational spaces.

Participants. Participating teachers are teachers of grades K-8 science. Survey respondents replied voluntarily to the needs assessment survey. Workshop participants will participate on their own time, to be compensated by the district with Continuing Education Units, professional literature books, and grants for classroom supplies. Most teachers in the district are late-career, fully credentialed, White or Latino females, but teachers most likely to participate in the workshop are early-career teachers for whom the CEUs are an attractive incentive.

Product Development Procedures

Product. The product is a plan for a day of professional development, based on a needs assessment survey and embedded in a wider implementation plan for NGSS in the district. The

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workshop plan includes five model lessons, forming a mini-unit of study leading to one Performance Expectation in the third grade Life Science topic of the NGSS. The lessons follow the 5Es model (Bybee, 2013), inviting the learner to engage, explore, explain, elaborate and evaluate in the course of an inquiry. Teachers will not only participate as learners in the science lesson, but will also investigate the inquiry model—in effect enclosing the 5Es within another set of 5Es. A brief outline of this plan is shown in Table 1.

Development plan. This product was developed using the following steps:

1. Survey teachers for their understanding of NGSS, their current practices, and their needs for moving forward with NGSS
2. Select an appropriate NGSS standard at the 3rd-5th grade band
3. Design a sequence of lessons to reach the Performance Expectation of that standard
4. Include lessons that highlight one of these Science and Engineering Practices:
 - a. #4 Analyzing and interpreting data
 - b. #6 Constructing explanations/designing solutions
 - c. #7 Engaging in argument from evidence
5. Incorporate three teaching strategies:
 - a. Science talks,
 - b. sketching from nature (Laws, Breunig, Lygren, & Lopez, 2012), and
 - c. the I² (Identify and Interpret) strategy (Biological Sciences Curriculum Study, 2012).
6. Send the 5-lesson sequence to reviewers for feedback

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7. Embed the lessons in a professional development format in which teachers reflect on the NGSS and the shifts it represents.
8. Include the workshop in an implementation plan proposed to the district.

At a future date, I plan to conduct the workshop and conduct a post-survey to evaluate changes in teacher confidence and familiarity with NGSS.

Materials. The needs assessment was created using Google Forms to build a survey instrument for teachers. In addition Google Forms was used to collect feedback from the model lesson reviewers. The lessons were based on some existing curricula, primarily The Growing Classroom (Jaffe & Appel, 2007), Opening the World through Nature Journaling (Laws,

Table 1

Five Steps of the 5E Model Applied to a Teacher Workshop.

Engage	Facilitator opens a discussion of what science learning looks like in elementary classrooms.	Teachers contribute their experiences with science teaching/learning.
Explore	Facilitator introduces the demo lesson sequence, including the structure of the NGSS standards to be addressed in the sequence.	Teachers examine the standard and predict what they might see during the investigation. They then participate in several embedded lessons.
Explain	Facilitator backs out of the inquiry lesson and asks teachers what they noticed about the “fit” of the lesson with the NGSS standard	Teachers report on attributes of the lesson that helped the learner develop Scientific and Engineering Practices (SEP), Crosscutting Concepts (CC), and Disciplinary Core Ideas (DCI).
Elaborate	Facilitator invites teachers to extend their ideas into how this would fit at their grade level and site	Teachers brainstorm ways the SEP, CC and DCI could fit in their classrooms.
Evaluate	Facilitator asks teachers to define what shifted in their thinking about NGSS instructional design	Teachers brainstorm shifts in thinking and instructional practice.

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Breunig, Lygren, & Lopez, 2012), and Creepy Crawlies and the Scientific Method (Kneidel, 1993).

Site. The workshop will take place in a school garden where teachers can actively experience the hands-on inquiry activities.

Data Collection and Data Sources

Quantitative and qualitative data about teacher's skills and attitudes were collected in an online Google Forms survey using a mix of Likert-style, checkbox, and text-response items. All K-8 science teachers in the district were invited to respond to the survey regarding current practices, attitudes, and student abilities in science. After the workshop, participating teachers will be surveyed again using a similar instrument to evaluate shifts in their practice and outlook on science teaching. Data was only collected by the researcher

Product Validation

Description. The workshop will be a trial for this type of professional development as an effective method of introducing NGSS as a framework for inquiry science teaching in the elementary grades. Its effectiveness will be assessed through the evaluations and post-workshop surveys of the participating teachers, as well as through expert review.

Qualitative Validating data were collected from six expert reviewers of the demonstration lessons. The reviewers evaluated the expected clarity, effectiveness and explicit connection to NGSS of the lessons. This feedback was used to revise and strengthen the lessons before the workshop. In addition, verbal feedback from participating teachers at the workshop will provide qualitative insight into the effectiveness of the workshop in supporting them as they begin to implement NGSS elements in their classroom instructional practice.

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Evaluators. Six evaluators reviewed the demonstration lessons.

- Colleen Bell, Director of Curriculum Development at Science Companion, has over 15 years experience in inquiry science curriculum development for elementary schools.
- Annie Holdren, Curator of Exhibitions at Pacific Grove Museum of Natural History, has been involved in environmental and science education for decades, and was an author during the development of the California Environmental Education Initiative curriculum.
- Whitney Cohen, Education Director at UCSC Life Lab, is the author of four books on school garden science learning. She coordinates professional development at the Life Lab demonstration garden at the University of California, Santa Cruz, and is in the process of aligning the Life Lab curriculum with the NGSS.
- Mark O’Shea, is a professor in the Education Department at CSU Monterey Bay who trains secondary science teachers and was involved in the review of NGSS at the state level.
- Vonneke Miller is a lecturer in the Education Department at CSU Monterey Bay.
- Maribel Villalobos teaches middle school science at El Sausal Middle School in Salinas.

Procedures. The needs assessment survey was designed by the researcher based on concerns expressed by the district’s superintendent, and was delivered to all teachers in the K-8 schools using an electronic link to a Google Forms survey instrument. Survey results were initially analyzed using the built-in results summary function, and then in more detail by exporting the data to Excel. This analysis revealed patterns of strength and gaps in science instructional ability that could be used to design the professional development workshop and implementation plan to meet the specific needs of the district.

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Another questionnaire developed by the researcher was delivered along with the lesson plans to the evaluators. This gave them a way to provide feedback as they considered the alignment of the professional development workshop plan with the NGSS and with their understanding of what teachers need as they shift into these new standards. The evaluators were asked to answer specific questions related to the expected effectiveness of the workshop in improving teachers' understanding of the new standards, confidence in developing inquiry learning experiences, and skill at incorporating the Science and Engineering Practices in lessons.

Using the needs assessment (Appendix A), I wrote both the series of lessons incorporated into a packet of materials for the introductory workshop, and an implementation plan for the phase-in of the NGSS in the district. Once the expert reviewers delivered their evaluations, I revised the workshop lessons accordingly. These two products are explained further in the Results section.

Limitations

This project was developed and carried out in a short time frame. This limits the ability to revise and improve the work in a timely manner. However, because the workshop is not scheduled for several months, further improvements are still possible.

The workshop is proposed as a full-day session without pay. Although some teachers may be willing to participate in order to acquire continuing education units, veteran teachers may not find this an appealing incentive. The workshop may have small or no attendance during the busy spring season, and for this reason there may not be much data on the impact of this workshop during the time frame available for the research.

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The subject district is small, rural, and remote from the few districts currently implementing NGSS. It is unclear at what point the district will implement these standards. Although the workshop will introduce aspects of the standards that can be applied immediately, and although this product is paired with an implementation plan intended to support ongoing professional development around NGSS in the district, wider support for NGSS-based instruction is not likely to arrive in the district any time soon. As a result, gains from this workshop may or may not find their way into instructional practice with the same fidelity that might be expected if this was part of an extended, district-planned implementation.

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Chapter Four: Results

Introduction

In April 2015, a small district in rural California invited its K-8 teachers to respond to a survey about current practices, future needs, and interest in using school gardens and habitat study sites for elementary science teaching and learning. In this survey, designed by the researcher (Appendix A), K-8 teachers in the subject school district reported a lack of familiarity with the NGSS and a desire to integrate sciences with other areas of the curriculum. The survey gathered information on (a) the needs of elementary science teachers making the shift toward the Next Generation Science Standards (NGSS), (b) the teachers' ideas about how school gardens and habitat sites may help meet these needs, and (c) the type of support teachers require from leadership in science teaching and learning.

Fifteen out of 34 teachers responded to the survey. Although identification was not required, seven teachers named the site where they work. Six of these were from one of the two schools, and only one was from the other school. Altogether, four middle school teachers, ten K-five teachers (four from grades 4 and 5, and six from grades K-2) and one "other" (special education/garden club sponsor) teacher responded. No third grade teachers responded.

Survey Results

The survey results (Appendix B) formed the basis of a recommended plan for professional development in science at the elementary and middle grades, including school garden integration. In addition, this survey provided design criteria for a workshop introducing teachers to the structure of the NGSS and the use of the garden as a platform for science inquiry. The results also informed the design of an implementation plan for NGSS in the district.

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Teachers' readiness for NGSS. Based on the narrative responses from participants, teachers teach many topics across the life sciences and earth sciences, but teach less in the physical sciences. This may have to do with teachers' need for stronger content area knowledge in the area of physical sciences. Teachers use a wide range of materials to teach science, ranging from published textbooks and trade nonfiction, to videos, Brainpop and Internet searches, to field trips (especially to life science-related sites like the Monterey Bay Aquarium, Science Camp, Elkhorn Slough, and Seymour Marine Lab), and guest speakers. These results indicate a corps of teachers who are flexible and adaptable, willing and able to seek resources that work for their science learners, and ready to learn more in content areas where they may have gaps. Most teachers report that they integrate many subjects with science, particularly language arts (80%), English Language Development (60%) and Arts (60%) (Figure 1). Nearly half of the teachers said that in the future they would like to integrate more math, social studies, and arts with science.

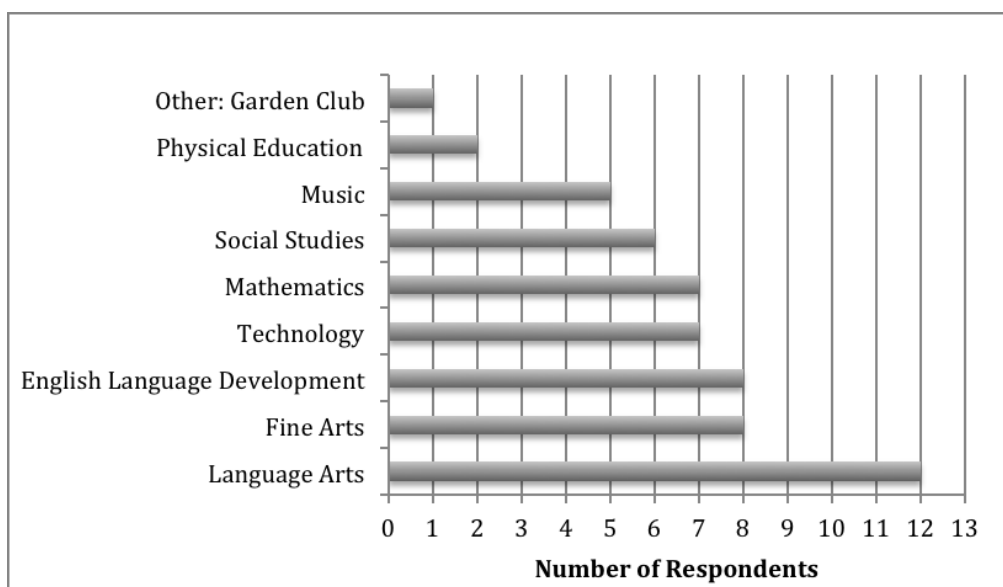


Figure 1. Subjects teachers reported they integrate with science. Twelve teachers (80%) integrate Language Arts, compared to seven (less than half)

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These skills and interest in integration will likely support teachers' transition to the NGSS well. These results do, however, point to a need for professional development focusing on integrating science with math, social studies, and arts.

Teachers are presently balancing inquiry with other, text-based science teaching methods in the elementary schools. Teachers rated themselves at a median score of five on a scale between no inquiry (0) and all inquiry (10). More than half of teachers rated their instruction at 50% or less inquiry (i.e. they rated their instruction closer to the text-based than inquiry-based end of the scale) (Figure 2). This may reflect a pattern arising from intensive focus on literacy at both schools over the past decade, or a lack of adopted curriculum in the district with an inquiry focus. This indicates that some active science instruction persists in these schools, in spite of the reduction in emphasis on inquiry science teaching and the pressure to teach from text over the past 20 years. It further suggests that teachers have a solid basis in inquiry but could develop in

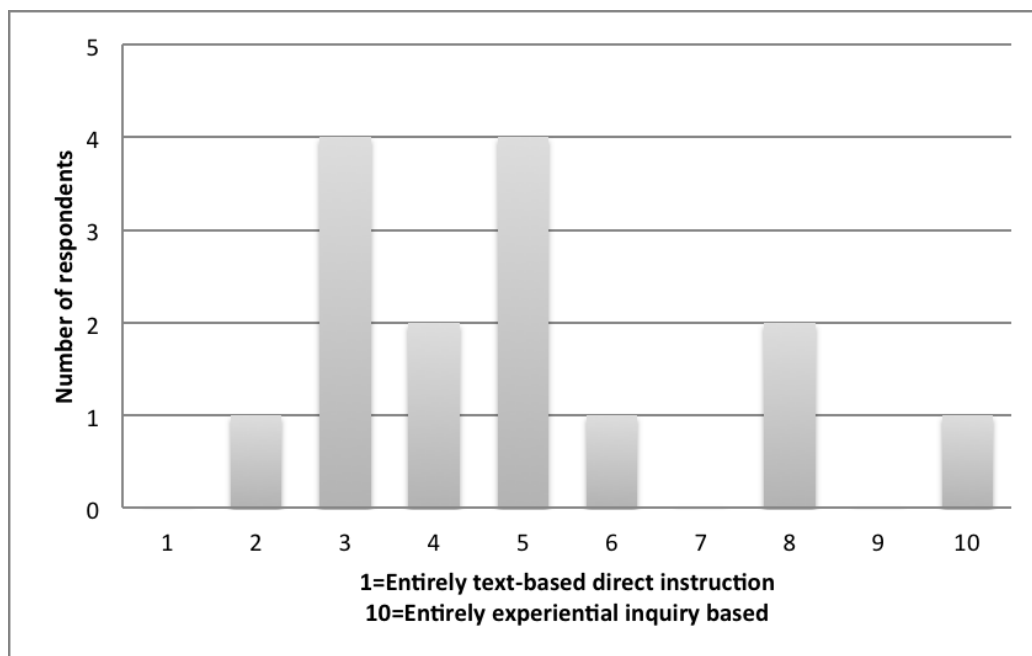


Figure 2. Teachers' estimate of how much text-based versus inquiry-based instruction they provide in science.

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the skills required for designing and implementing inquiry-based learning opportunities, in order to shift the center of their instruction toward hands-on, evidence-based curriculum with text as support for the experiential learning

Compared to their confidence with inquiry, teachers were more confident (median of 8) about their ability to integrate mathematics, fine arts and language arts with science (Figure 3). This skill set will help teams of teachers integrate some important dimensions of the NGSS across the curriculum. For example, their skill at integrating mathematics will help them support the Scientific and Engineering Practices of analyzing data and using computation in science (#4 and #5), while their ability to integrate fine arts will help them support students developing and using models (#2) as well as communicating information (#8).

These results indicate that teachers have a moderate level of confidence in integrating science with other curriculum, although they would like to improve their ability to integrate science with social studies, and to further develop their skill in integrating math and fine arts. By

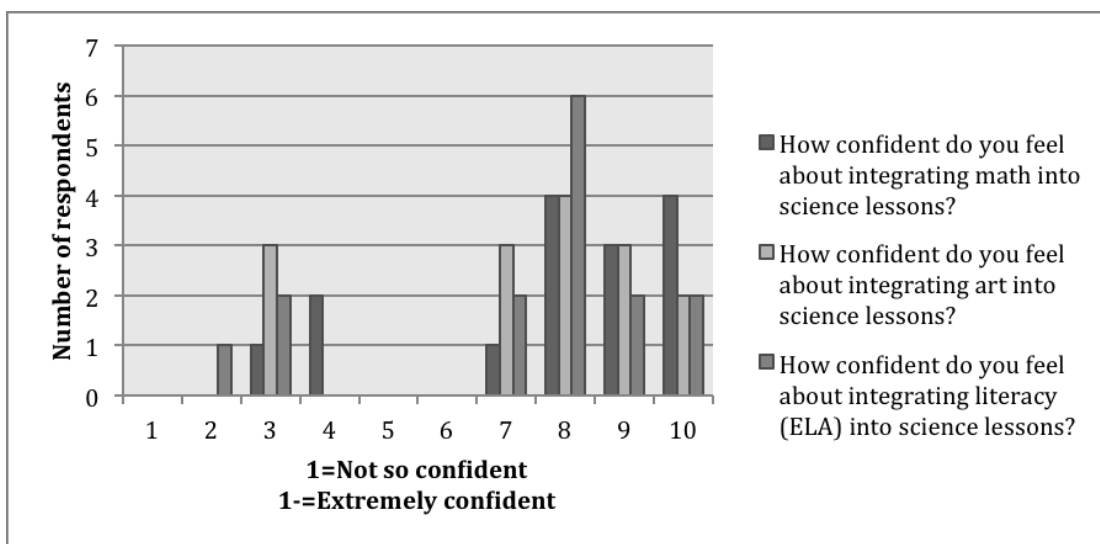


Figure 3. Teachers' confidence in their ability to integrate math, art, and literacy into science lessons.

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far, the largest group of teachers reported feeling confident about integrating language arts with science, which suggests that the future science program in these schools will be rich in connections to the Common Core State Standards in English/Language Arts. Because this district, like many others in California, has focused intensively on literacy development over the past decade, these teachers bring to the new efforts in science education both confidence and skill in helping students comprehend and make use of informational text. In fact, each school already has individual teacher-experts in integrating every subject area and who, in the course of on-site collaborative work on developing units of science study appropriate for NGSS, could serve as leaders for the colleagues in developing the skills of integrating disciplines with science.

The respondents rated themselves at a median score of six on a scale of 0-10 for their confidence both in facilitating science conversations and in designing inquiry lessons (Figure 4). This indicates that there is a good base for building additional skill as teachers embed the NGSS into future units of study. Because the NGSS is highly dependent on collaborative conversations and communication, on arguing from evidence, and on formulating questions and seeking answers, this existing skill base will be an important foundation for reshaping science education in the district.

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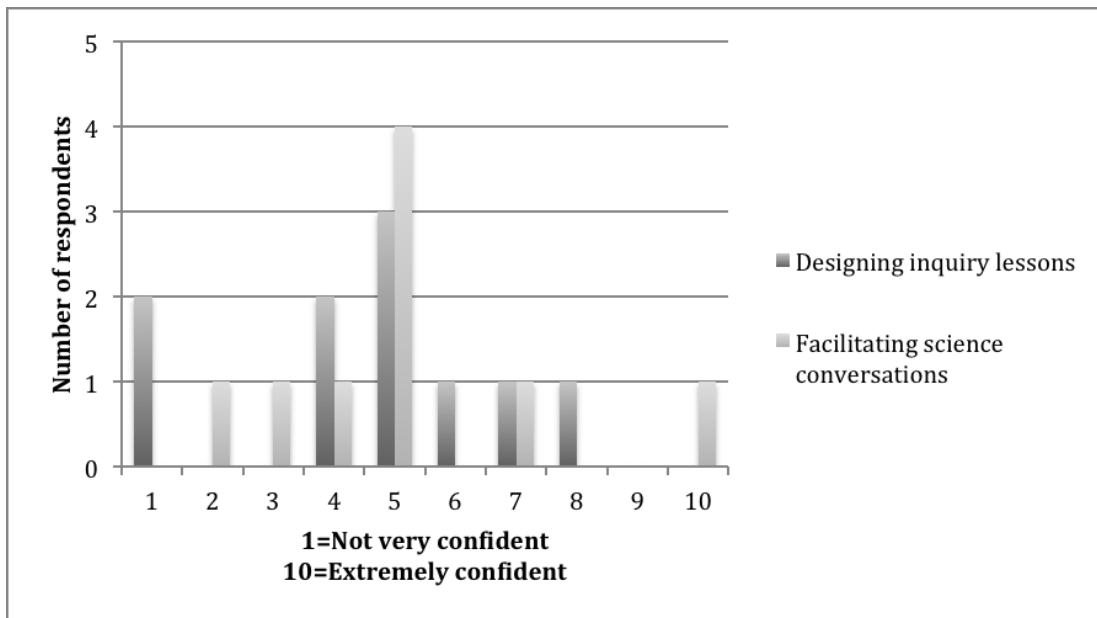


Figure 4. Teachers' confidence in their ability to design inquiry and facilitate science conversations.

Students' readiness for NGSS. Teachers report that their students are not very able to analyze mathematical data in science (median of four on a scale of 1, not able, to 10, very able) (Figure 5). This is an area of critical need, not only for meeting the NGSS but also for reaching the Common Core State Standards in Mathematics. Both sets of standards depend on students

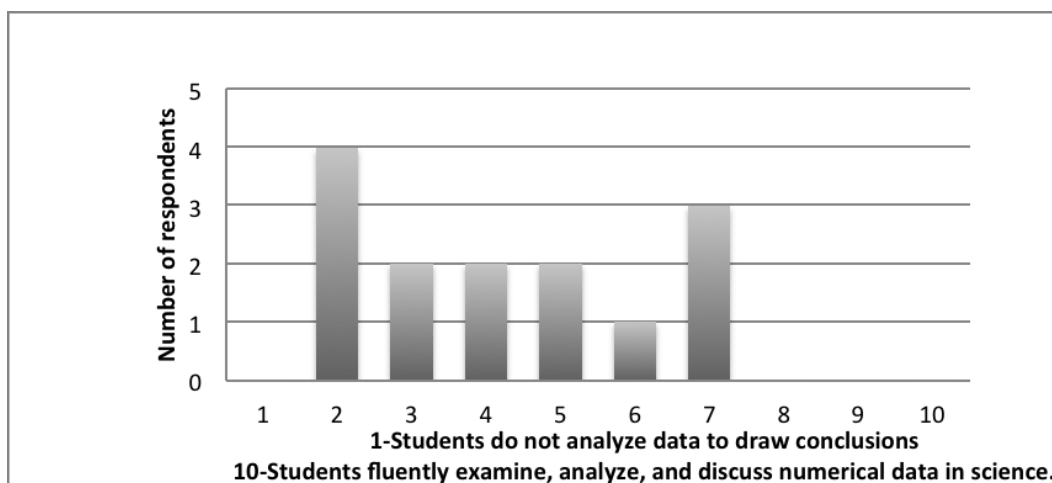


Figure 5. Teachers' perceptions of students' ability to analyze data in science.

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being able to use mathematical reasoning to solve real-world problems. Two of the Scientific and Engineering Practices in the NGSS depend on mathematical skill (#4, Analyzing and interpreting data, and #5 Using mathematics and computational thinking), and all eight Standards for Mathematical Practice outlined in the CCSS can be applied to mathematics in science. This implies that teachers will need to look carefully at opportunities to coordinate instruction in mathematics with units of science inquiry so that the science activities provide opportunities to put to practical use the concepts students are learning in math.

In addition, teachers expressed a students' lack of readiness to use evidence as a foundation for their conclusions, with a median score of three out of 10 (Figure 6). This skill is fundamental to all three sets of standards (NGSS and CCSS Math and Language Arts standards). Whether students are critiquing a classmate's argument in math, defending an interpretation of text in Language Arts, or constructing an explanation in Science, they must ground their discussion in evidence gathered from text, experience, or observation.

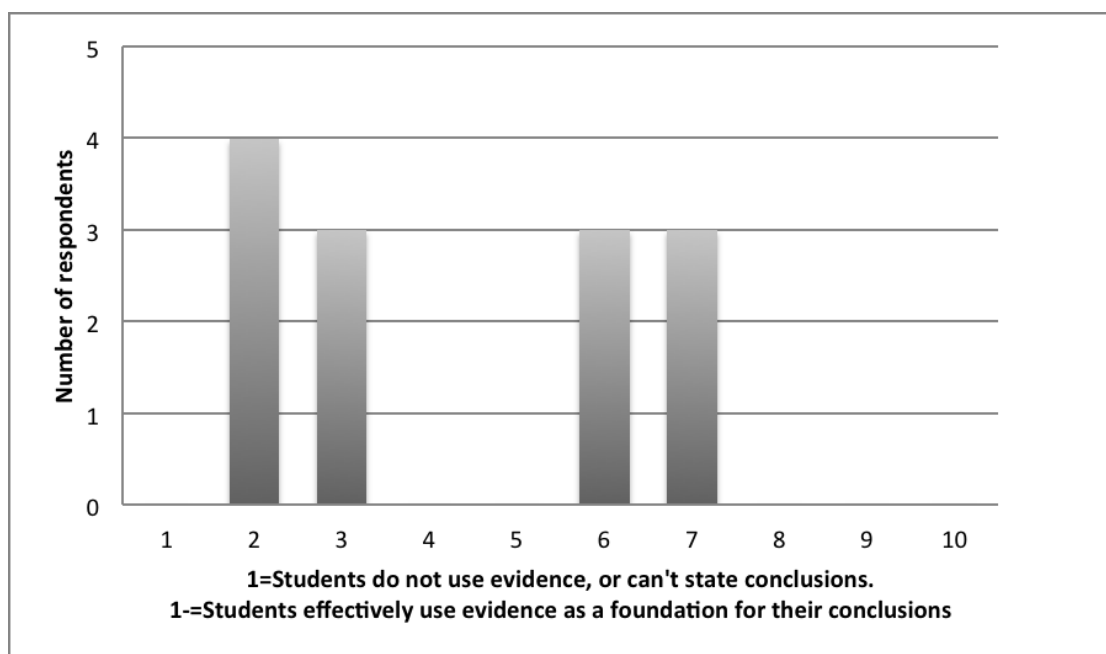


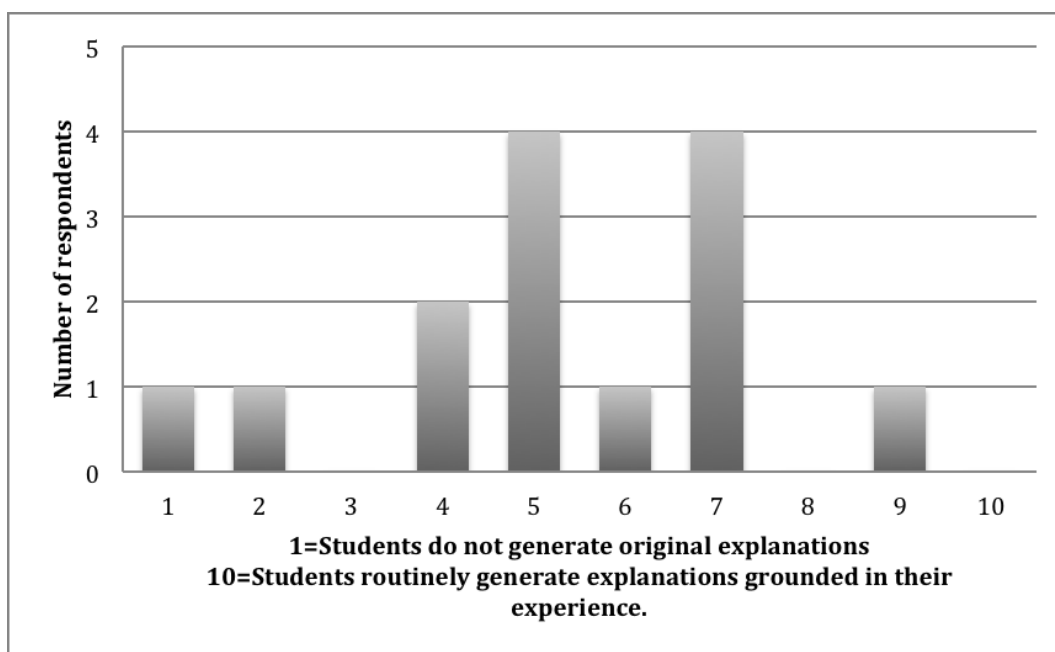
Figure 6. Teachers' perceptions of students' ability to generate original explanations.

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A related gap in students' readiness for the NGSS is evident in the teachers' assessment of their students' ability to explain their scientific thinking based on experience. They rated this ability at a median score of 5—stronger than their ability to use evidence or mathematical data, but with plenty of room to improve (Figure 7).

Teachers described other obstacles to student achievement in science, including limited English language proficiency, low reading comprehension, unfamiliarity with using evidence other than from text, lack of time allocated for instruction and professional development in science, a shortage of materials, and a need for leadership to support science teaching and learning. There is a strong thread in teachers' comments about how students learn best: they believe that hands-on learning works best for their kids, and they hope that leadership will help them create more hands-on science opportunities in their classrooms and outside.

Next Generation Science Standards. Teachers' awareness of the Next Generation Science Standards is limited, perhaps because the recent focus of professional development has



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been on the Common Core standards in English/Language Arts and Math and because the NGSS are still so new that they are only being implemented in eight pilot districts in California. Within this district, one third of teachers have never heard of the NGSS, and 12 out of 15 respondents have never seen the standards (Figure 8). This is probably not unusual at this time in California, where only eight districts are acting as early adopters, none of them near this district, but it means that if the district is to move forward with NGSS at the elementary and middle school level, the first step is to make teachers aware of the standards and what they mean for instruction.

Teachers recognize that their lack of familiarity with the standards means that they will need support to use them effectively (Figure 9). Looking forward to working with these new standards, more than half the respondents asked for support in the form of content information, formal training on the standards, collaboration time, and teacher-produced units to share. A third

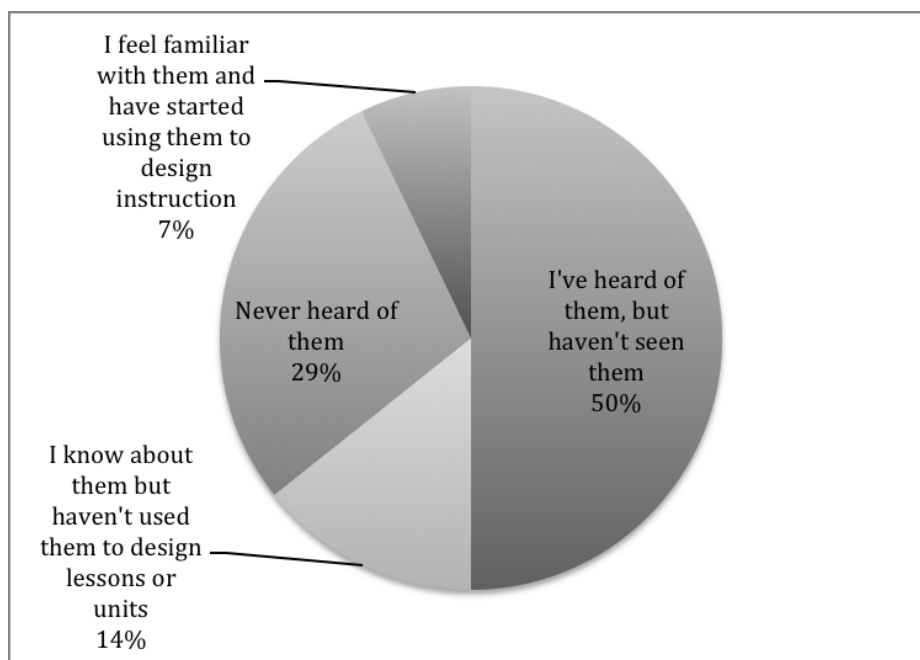


Figure 8. Teachers' familiarity with Next Generation Science Standards.

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of teachers requested coaching in science teaching, and nearly half requested professional development. But two thirds of teachers said they needed equipment to teach science effectively, and nearly all said they need funds to support field trips. Without appropriate equipment it is difficult to lift instruction away from the printed page, and without field trip funds it is hard to expand students' awareness beyond the classroom walls.

School gardens and habitat sites. Both elementary schools have school gardens, but few teachers use these resources for teaching. Sixty percent of the respondents report that they never use the garden at all, and four of the respondents, over one in four, use it only a few times a year. Only one teacher, who uses the garden for extensive observations, reported using the garden more than a few times a year; one more does some planting and donates plants to the garden. Some teachers do individual planting projects in the classroom rather than any extended or year-round garden studies. One teacher reported that it is not “on the radar” in school discussions. Teachers described needs such as a designated coordinator, leadership support, tools, space,

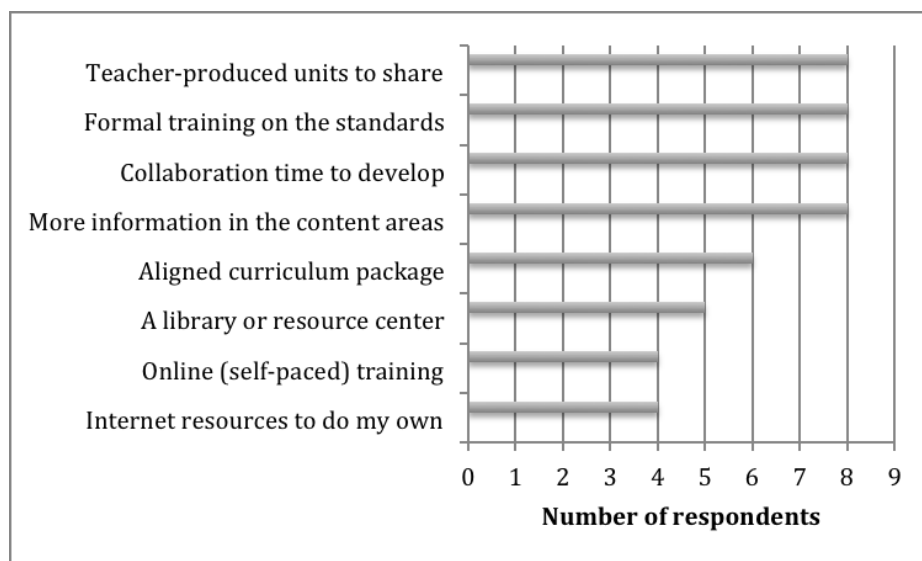


Figure 9. Teachers' needs for preparing for Next Generation Science Standards.

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raised beds allocated for classes, and outdoor furniture. Several expressed frustration at the way that tools and structures have been damaged or lost over time since the gardens were constructed, making it more difficult to do gardening with kids at all. Teachers state that with leadership support and better infrastructure (an aide, furniture, and boxes designated for classes) they would be more likely to use the garden especially to grow (and eat!) fruits and vegetables as well as ornamental flowers and native plants.

Habitat learning site. There is strong support among respondents for adding a habitat garden as an element of outdoor science learning at each of the schools. A third of the teachers responding rated their likelihood of using such a site at eight out of ten (with a rating of 10 meaning “I’d use it all the time!”); the median score was 5. Of a list of possible features for a habitat site, the three most popular were a small pond (67%) with tables (60%) on the school site (60%). At one site, teachers remembered whole units of study framed around the nearby river, but property ownership changes appear to have limited student access to the site the school once used

General thoughts. Teachers’ closing comments reflect the following general sentiments, which are also expressed in the earlier parts of the survey:

- perception that district and school leadership do not at this point support garden or habitat based science,
- frustration about a lack of materials, funding, and other resources, and
- conviction that hands-on science is fascinating, motivating, and effective for students.

In general, these impressions do reflect a desire to see more science, and more quality science, going on at the elementary schools, in spite of the perceived obstacles..

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Product

After receiving these results, I developed a plan to conduct a one-day workshop introducing the NGSS within the context of the school garden. This including creating a highly compressed learning unit to illustrate the three dimensions of the NGSS, using five lessons to demonstrate the 5E model (Engage, Explore, Explain, Elaborate, Evaluate) presented by Rodger Bybee (2013). The lessons were aimed at a single Performance Expectation in the Grade 3 standards (Appendix C). The packet of lessons designed for use by teachers at the workshop is included as Appendix D. I contacted 12 expert reviewers with a request for feedback, and six responded, as listed in Chapter Three.

The reviewers were asked for the following ratings on each lesson, using a Likert scale from one to five:

- How well does this lesson serve to move students toward the performance expectation of the targeted NGSS standard?
- How clear is the connection between this lesson and the structure of the NGSS?
- How well does the content and structure of the workshop serve to illustrate the type of instruction NGSS implies for elementary science education?
- How well does this lesson highlight methods and reasons for using the garden for NGSS science education?

In addition the reviewers were asked to comment on the overall content and structure of the workshop and on the connection between the activities and the school garden setting. The ratings are tabulated in Table 2, and the complete text of the reviewers' comments is included as Appendix E. Five reviewers provided numerical feedback, and one provided only detailed

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narrative comments that could not be included in the scoring table. The comments fell into several general categories, and I revised the materials accordingly as described below.

Connection to the elements of the standards. One reviewer noted that definitions for key terms in the NGSS were missing from the document. Reviewers felt that although the Science and Engineering Practices and the Disciplinary Core Ideas were present in the activities, they were not highlighted in the materials in a way that teachers new to the standards would be able to recognize. The Cross-Cutting Principles were not evident at all, at least to one reviewer. For this reason, graphic organizers were added to each demonstration lesson to identify the three dimensions from the Performance Expectation being targeted in the workshop and to allow participants space to take notes on the lessons. In addition, a definitions section was added including text drawn directly from the NGSS front matter, along with diagrams highlighting the relationship between the elements of the standards.

Table 2
Expert Reviewers' Ratings of Five Lessons Included in Workshop Packet.

Qualities evaluated for each lesson		Moves toward Performance Expectation	Connects to NGSS structure	Illustrates NGSS instruction	Highlights methods and reasons for using the garden
<u>Lesson title</u>	<u>5E Phase</u>				
Imagining Habitat	Engage	5.0	5.3	4.8	4.8
Field Collecting	Explore	4.2	4.6	5.0	5.0
Drawing/Observing Up Close	Explain	4.8	5.0	4.8	4.4
Analyzing Data	Elaborate	4.8	4.8	4.8	4.5
Designing Habitat		4.8	5.0	5.0	5.0

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Effectiveness of teaching methodology. The reviewers made a number of significant suggestions for improving the specific approach of the lessons. For example, one reviewer recommended, rather than telling students how to determine the moisture and temperature of a location, allowing students to establish and agree on ways to decide what constitutes dry, moist, or wet substrate, or hot, warm or cool locations. This was included as a suggestion in the demonstration lesson plan.

One reviewer suggested that, in the diagramming activity, the connection between the drawing and the learning goal of connecting adaptation to survival was not strong enough. Another commented that teachers would need more specific instructions to facilitate student recall of the association between animal and micro-habitat as they moved away from observations into the diagramming activity—stating “If there was an association between which animals were found where, you’d have a closer shot at LS4.C. (“Particular organisms can only survive in particular environments.”), e.g. ‘Could a worm live on a dry garden path? Could a butterfly live inside a compost heap?’ ” Based on this, the teacher instructions preceding the diagramming activity were fortified with a science talk inviting students to share their anecdotal observations of which animals were found where.

Cross Cutting Concepts. This sequence of lessons is intended to reach a Performance Expectation from the NGSS. It highlights three of the eight Scientific and Engineering Practices, but, as one reviewer pointed out, the lesson sequence does not effectively illustrate the Cross-cutting Concept identified in the standard: Cause and Effect (“Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.”) (NRC, 2013) This, like other

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elements of the referenced Performance Expectation, can be seen in Figure 10; the standard is also included as Appendix C and within the workshop materials in Appendix D.

Because there is no cause-and-effect sequence of events related to observing an organism and designing a habitat for it, it's hard to find a way to pull this particular Cross Cutting Concept into this sequence of lessons. However, it was possible to highlight other Cross Cutting Concepts within the five lessons. This may be less a fault in the lesson sequence design than an indication that the cross-cutting concepts may be applicable in instructional situations other than those envisioned by the drafters of the standards, and that investigations with students may yield unexpected opportunities for bringing them forward.

3-LS4-3 Biological Evolution: Unity and Diversity		
Students who demonstrate understanding can:		
3-LS4-3. Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all. [Clarification Statement: Examples of evidence could include needs and characteristics of the organisms and habitats involved. The organisms and their habitat make up a system in which the parts depend on each other.]		
The performance expectation above was developed using the following elements from the NRC document <i>A Framework for K-12 Science Education</i> :		
Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence Engaging in argument from evidence in 3–5 builds on K–2 experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world(s). <ul style="list-style-type: none"> Construct an argument with evidence. 	LS4.C: Adaptation <ul style="list-style-type: none"> For any particular environment, some kinds of organisms survive well, some survive less well, and some cannot survive at all. 	Cause and Effect <ul style="list-style-type: none"> Cause and effect relationships are routinely identified and used to explain change.
<i>Connections to other DCIs in third grade:</i>		
3.ESS2.D		
<i>Articulation of DCIs across grade-levels:</i>		
K.ESS3.A ; 2.LS2.A ; 2.LS4.D ; MS.LS2.A ; MS.LS4.B ; MS.LS4.C ; MS.ESS1.C		
<i>Common Core State Standards Connections:</i>		
<i>ELA/Literacy —</i>		
RI.3.1	Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers. (3-LS4-3)	
RI.3.2	Determine the main idea of a text; recount the key details and explain how they support the main idea. (3-LS4-3)	
RI.3.3	Describe the relationship between a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text, using language that pertains to time, sequence, and cause/effect. (3-LS4-3)	
W.3.1	Write opinion pieces on topics or texts, supporting a point of view with reasons. (3-LS4-3)	
W.3.2	Write informative/explanatory texts to examine a topic and convey ideas and information clearly. (3-LS4-3)	
SL.3.4	Report on a topic or text, tell a story, or recount an experience with appropriate facts and relevant, descriptive details, speaking clearly at an understandable pace. (3-LS4-3)	
<i>Mathematics —</i>		
MP.2	Reason abstractly and quantitatively. (3-LS4-3)	
3.MD.B.3	Draw a scaled picture graph and a scaled bar graph to represent a data set with several categories. Solve one- and two-step "how many more" and "how many less" problems using information presented in scaled bar graphs. (3-LS4-3)	

Figure 10. NGSS Standard 3-LS4-3 Biological Evolution: Unity and Diversity

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Practicalities of the lessons. Some of the reviewers provided useful logistical suggestions, such as providing hints on where to find garden animals (shaking bushes, turning over logs and rocks), adjusting worksheets to include important data (time and date, a name -- conventional or invented -- for the animal, and extra space for notes while in the garden), and graphic organizers for the text-based lesson. These suggestions were useful in fine-tuning both the student materials and the teacher instructions.

Summary

This project's goal was to answer several questions about professional development as districts move toward implementation of new science standards:

1. What are the key needs of elementary science teachers making the shift toward the Next Generation Science Standards?
2. How can a district support teachers in moving toward Next Generation Science Standards implementation?
3. How can school gardens and habitat sites help science teachers meet these needs?

NGSS-shift needs. The results of this project indicate needs for elementary science in several key areas. Based on the survey of K-8 teachers, they need professional development in the following areas in order to teach with the Next Generation Science Standards:

- The nature and structure of the standards
- Methods for designing units of study aligned with NGSS
- Strategies to integrate other disciplines, e.g. math and fine arts, with science
- Ways to evaluate and select from available curriculum and other resources

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Expert review of a workshop designed to introduce teachers to the new standards indicated that this could be an effective way to help teachers begin this work and to begin using the garden as an integral tool for NGSS teaching and learning.

District support for NGSS. In addition, the teacher survey showed a need for support from the district to move forward into new ways to teach science, such as:

- Resources for developing science content understanding among teachers
- Financial support for field trips, equipment, and quality texts
- Opportunities to collaborate on elementary curriculum design for NGSS
- Opportunities to articulate elementary and middle school scope and sequence with high school curriculum

Gardens and habitats. Teachers expressed interest in using the gardens and in developing habitat sites for learning, but clearly outlined some needs for support from the district to ensure these resources function effectively to support NGSS science:

- Leadership support for using the gardens as learning sites, including scheduling
- Assigned staff (aide) to maintain the gardens, prepare lessons, and help teachers teach in the gardens, and to develop ongoing financial and community support for the gardens
- Resources to improve the gardens, especially tools and furniture, automated water-conserving irrigation systems, and, at one school, a design and new garden beds.
- Training for teachers on how to utilize the gardens to meet current and future standards (e.g. UCSC LifeLab's [The Growing Classroom](#))

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Similarly, the native habitat sites were perceived as valuable teaching and learning assets, requiring support from the district to be fully successful. Teachers hoped for the following:

- Design and construction assistance, including appropriate siting for safe access, class seating, and staffing to develop and maintain the sites
- Professional development for teachers on content (California ecology, water education, etc.) and ways to integrate habitat learning with existing and future curriculum
- Staffing to develop financial and community support for this habitat learning initiative

The first step toward meeting these needs can be a workshop to introduce the standards in a hands-on, experiential learning environment. Using the garden as a workshop site can help the district meet its goal of increasing visibility and use for the gardens. This will also demonstrate the district's commitment to moving forward with inquiry science education. These results, in the form of an implementation plan integrating garden learning with NGSS implementation, are further explained in Chapter 5, and shape a path toward rigorous and engaging inquiry science education for elementary and middle school students.

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Chapter Five: Discussion and Implications

Introduction

This research examined the needs of elementary science teachers in districts moving to implement Next Generation Science Standards, an approach to teaching and learning science that merges constructivist pedagogy with opportunities for students to practice the behaviors and thinking habits of professional scientists and engineers. This shift holds many similarities to the experiential science era of the 1960s, particularly in the way that students participate actively in investigations that lead to their own discovery of scientific principles, guided by a teacher who acts as a fellow explorer.

This model represents a dramatic departure from the educational environment of the 1990s and 2000s, when text-based instruction left little time for hands-on science in many classrooms, schools, and districts across the United States. The Next Generation Science Standards are now in the early phases of implementation, and this is the ideal time to help teachers become familiar with the standards and the changes they imply.

This project examined the needs and strengths of elementary science teachers shifting toward NGSS in one school district, and explored ways to build on strengths and meet those needs. Because this district has an underutilized garden at each elementary school site, I also investigated teachers' needs and interests regarding using existing school gardens as a platform for supporting NGSS learning. Last, I created an implementation plan (described here, and a timeline outlined in Appendix F) to guide the district in helping teachers move into NGSS, including detailed plans for a workshop to explore the standards.

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Limitations

The workshop materials developed in the course of this research have been reviewed by six experts in the fields of science education, environmental education (including school garden learning), and curriculum development. However, the proposed workshop was never tested with real teachers, on a real timeline. Actually presenting the workshop is problematic, because the district lacks the discretionary funds that would be needed to provide incentives for teachers to attend, such as stipends, materials (such as curriculum books, garden art and science tools, etc.), or even lunch. Teachers deserve to be supported and recognized when they take the time to learn new skills and practices. Without such incentives, few if any teachers would attend this type of workshop no matter how engaging it is.

The plan assumes financial support for elementary science from within the district and from supporting organizations such as foundations and local businesses, as well as coordinated leadership support between the district and the three principals. School district budgets are always tight, and setting priorities for funding is a process of trying to meet many competing needs. This district is too small to have personnel dedicated to seeking outside funding, but supporting and developing the gardens, and the funding the professional development envisioned in this implementation plan will require some creative fundraising to pay for workshops, collaboration time, and needed physical improvements to the outdoor learning spaces. Without outside funds this plan may be impossible to implement.

A further limitation of this project is the uncertainty about how the district will choose to move forward, and the fact that the implementation plan was developed with little opportunity to collaborate with district stakeholders other than the superintendent and one

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trustee. The implementation plan is based on my own research into the field of inquiry science education and the advent of the NGSS, on the results of the teacher survey, and on my own observations of issues and resources in the district. It has not yet been reviewed or revised by district personnel, though it is my hope that it will form the basis of an implementation plan the district will adopt formally. Until the Board of Trustees and administration look at it carefully, it's hard to know if it is realistic.

Although the superintendent is highly supportive of innovation in science education, and the high school administration and staff are already moving ahead with revising curriculum to meet the new standards, at the elementary level there is much less drive and considerably less awareness of the NGSS. For this initiative to take root, the elementary principals will need to step up and make science a priority for professional development, supporting teachers as they build the content knowledge and pedagogical skill required for inquiry science. Teachers responding to my survey consistently indicated a lack of leadership for science, including for the school gardens, at both elementary schools. In contrast, the high school principal has been very supportive of the high school science team as it moves forward with NGSS planning. However, the success of the high school science program depends on the preparation of elementary and middle school science students, and that depends on leadership in the K-8 schools.

Implications

This District, like many districts in California and across the country, is looking forward to implementation of the Next Generation Science Standards. Although full implementation is several years' away, district leadership (the superintendent and Board of Trustees) hope to provide support in the years leading up to full implementation so that teachers will be well

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prepared in advance. However, at this time it appears there are large gaps in understanding of the standards and their implications for teaching and learning. These gaps quite likely exist in many or most other districts in California and perhaps across the country as districts move toward new approaches to science instruction, including integration with environmental education such as school gardening, watershed awareness and other environmental literacy curriculum opportunities.

Shifting to evidence-based teaching and learning. Teachers reported that students lack skill at constructing explanations, analyzing data, and arguing from evidence. This may be a result of many years of student experience with text rather than hands-on interaction with scientific phenomena. Students may be unaccustomed to experimentation and observation, and are perhaps more familiar with reading for science information and with conducting labs with predictable or pre-determined outcomes.

Teachers will need to develop skill at helping students make observations, create explanations, and then test those explanations by repeating or extending experiments. Similarly, teachers will need support in coaching students' efforts at engineering, which depends on the ability to develop and refine a design based on experience, and to tolerate some failures on the road to success.

Moving into the NGSS, teachers will need support, tools, and opportunities to collaborate as they find ways to develop the skill of independent reasoning in a population of students accustomed to absorbing and accepting factual information from text or lecture. Collaboration can help teachers work together to find ways to make the use of evidence explicit in their teaching across the curriculum, since this skill is common to the math and language arts

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Common Core State Standards as well as the NGSS. The survey results thus suggest that the district could support teachers by providing collaboration and professional development time, adjusting schedules to make time for science, and especially by setting science education as an explicit priority at the school and district level. This professional development can begin with an Awareness phase, helping teachers understand the structure and intent of the NGSS, and then move toward a Transition phase of experimenting with unit design by grade level. In each of these phases, the district can support development in (a) shifting to evidence-based learning across the elementary curriculum, (b) articulating the science scope and sequence throughout the grade levels, and (c) integrating gardens and habitat sites with science learning. In this way, teachers will be well prepared for the Implementation phase when NGSS is fully integrated into classroom instruction.

Articulating science from kindergarten through high school. Teachers will need training to understand the standards and how they will shift science teaching in elementary classrooms, as well as what must happen in elementary and middle school science to prepare students for NGSS in high school. The district may be able to capitalize on strong interest in professional development and on the existing skill base in creating curriculum to facilitate local development of NGSS units. Elementary and middle school units of study should integrate with the high school's path-breaking work on articulating the NGSS. For this reason, the district should coordinate professional development across all three grade bands: elementary, middle and high school. For example, elementary teachers could team by grade level to design units that are locally relevant and respond to the new national science standards. Representatives of these teams can collaborate between grade bands and between schools to ensure that the NGSS cross-

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cutting concepts, science and engineering practices, and disciplinary core ideas are articulated from kindergarten through high school and linked to the Common Core State Standards in math and English language arts.

Although a team of high school teachers from the district has already attended one of the state-sponsored NGSS Rollout Symposia, no elementary or middle school teachers were able to join them. The Rollout Symposia, which continue through 2016, open an opportunity for the district to create a team of lead science teachers who are motivated to join the high school team in creating an articulated science program for the entire district, taking advantage of the state's efforts to provide district teams with opportunities to explore, understand, and implement the standards over the next several years, from awareness to transition, to implementation. These teachers can be partners between schools and across grade levels to create locally responsive curriculum to carry students into a new way of investigating science.

Gardens and habitat sites. The survey results indicate a strong need for leadership to support the gardens as learning labs, specifically by providing staff to co-teach lessons and maintain the gardens, tools for kids to use in the garden, and furniture or improved planting beds to make the garden physically useful for learning. In addition, the district can support teachers by offering professional development with organizations like LifeLab and The Edible Schoolyard to build capacity with integrating garden learning with NGSS, with CCSS, and with health and nutrition standards.

The survey results also indicate that teachers would be very interested in using a site-based habitat study area. In addition to supporting physical development of such an onsite habitat, the district can support teachers in learning how to use environmental curricula including

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those provided by the state Environmental Education Initiative (CalRecycle, 2015), LifeLab (Jaffe & Appel, 2007), Project WET (Project WET Foundation, 2015), Project WILD (Project WILD, 2012), and Project Wild Aquatic (Project WILD, 2013), all of which provide lesson plans with connections to the NGSS as well as training for teachers at no or low cost. All of these organizations are presently working to align their curriculum with NGSS, and teachers with a solid understanding of the standards would be able to use their materials effectively with the habitat sites in designing units of study to meet NGSS performance expectations.

Action Plan

The district can address these gaps and move forward with confidence toward NGSS implementation by

1. Identifying a lead teacher team
2. Providing time and resources for professional development and for collaboration
3. Funding resources, including school gardens, materials, and field trip funds

With support from leadership and a base of experience among the teaching staff, the district is ready to follow the implementation sequence of the State Board of Education. The high school staff has already begun this process, and is welcoming the K-8 staff to join them. This plan begins from the point in time at which the elementary teachers have little or no awareness of the new standards, and moves forward toward full implementation either with teacher-developed or with published NGSS-aligned curriculum, or a combination of both.

Awareness Phase. The present moment is the midpoint of the Awareness phase statewide, an appropriate time to expand teachers' awareness of the NGSS within the district. During this phase, teachers at the high school have already participated in the first round of

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NGSS Rollout Symposia sponsored by the State Board of Education and the California Science Teachers Association. One school's teachers have participated in an Environmental Education workshop that touched on the NGSS in the context of the Environmental Education Initiative. The next step within the Awareness phase is to address teachers' lack of understanding of the standards by offering an introductory workshop highlighting the dimensions of the standards in a participatory set of lessons, using the demonstration lessons developed as part of this project (Appendix D) or another set of lessons that form a mini-unit of study leading to a Performance Expectation within the K-8 grade range.

As awareness grows within the district, teachers will need support in implementing NGSS dimensions within their teaching. This work can be carried out collaboratively within grade levels, but teachers will need specific training on how to integrate the three dimensions of the NGSS in their teaching. Lead teachers in each grade band and from each school can serve as coaches for this work. They will first strengthen their own understanding of the standards by attending one of the state's Rollout Symposia. Although the window for attending the first rollout has passed, this group of teachers can use online resources and the advice of the high school team to catch up on what they missed. Then they can pass that information on to colleagues.

In addition, teachers can take advantage of online independent learning opportunities. For example, the National Science Teachers' Association website (nsta.org) offers its members self-paced assessments and digital content learning opportunities in the form of webinars and online courses. Stanford University's Understanding Language group offers free Massive Open Online Courses every quarter, often featuring strategies for improving conversations in content areas in

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the classroom; teachers may choose to join these as individuals or in teams. The Environmental Education Initiative also offers free webinars. This type of resource can enable teachers to delve into the standards in ways that meet their individual needs; the science team leaders can help by locating and promoting these resources.

Similarly, in order to become experts at integrating math teachers will need to seek professional development in the area of data analysis. Examining links between the NGSS and the newly and recently adopted math materials in the district will support this need, and strengthening the use of the I² (Identify and Interpret) (BSBC, 2013) model of data analysis will help integrate statistical mathematics with science. Introducing teachers to the tool of the science notebook, or enhancing their existing use of notebooks, will help build bridges between science, art, and literacy; the work of the California Native Plant Society (Laws, Breunig, Lygren, & Lopez, 2012) can support this work.

In the fall of 2015, when the lead teachers attend NGSS Rollout #2 along with their counterparts from Anzar High School, they will begin the process of collaborating from kindergarten through 12th grade, building toward a team that can articulate science teaching and learning throughout the district. In addition members of this team will attend the annual California Science Teachers' Association meeting in October in Sacramento to stay abreast of developments in NGSS implementation, and should connect with NGSS implementation efforts throughout San Benito County as well as in neighboring Monterey and Santa Cruz Counties if possible. These activities will help them develop strategies to share the NGSS with their colleagues at their site.

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Throughout the 2015-2016 school year, the district will dedicate some of its Wednesday minimum-day times to NGSS awareness, training, and collaboration in the specific areas of need teachers have noted, particularly in the use of evidence and the analysis of data to draw conclusions. These workshops can be framed in the context of available environmental curricula in order to take advantage of available resources while developing skill at using the standards. For example, Project WET offers teachers a 6-hour hands-on workshop focused on water, with free teacher materials and available continuing education credit. A Project WET workshop could help teachers utilize free curriculum (Project WET, 2015) as they investigate ways to incorporate the NGSS dimensions in their teaching.

In this first year, teams of teachers will co-create one unit of study per grade level, investigating just one performance expectation and building a learning sequence to help students achieve it. This will require several collaborative days dedicated to the NGSS once teachers are familiar with the standards. Later in the year they will reflect on the unit's effectiveness, consider what they need to do to improve it, and document it in order to be able to teach it again in subsequent years.

Simultaneously, a garden coordinator will be revitalizing garden education at the K-8 sites. By co-teaching with the K-8 teachers, the coordinator will help bring NGSS standards to life with investigations in the natural world. The school gardens offer opportunities to integrate science with social studies, arts, mathematics, and language arts, and over the course of the awareness period teachers will create and document lessons that take advantage of the garden resource.

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In the first year, both schools will focus on creating native habitat gardens, a project that lends itself to yearlong research, implementation, and community outreach by the fifth grade classes heading up the work. Meanwhile, the garden coordinator, fifth grade teachers, and lead science team will collaborate to find best ways to continue to use the gardens (and to redesign the garden at one school) to meet the needs of the school community and the emerging NGSS science curriculum. During the year and/or in the summer, teams of teachers most involved in the garden effort will attend workshops at LifeLab or The Edible Schoolyard to build their skill at maintaining and utilizing the gardens.

Transition Phase. In the Transition Phase, the lead team will continue to attend state-wide professional development, and the district will continue to encourage teachers to attend local professional development opportunities featuring NGSS connections, in addition to what the lead science team can provide on early-dismissal days. The science team will conduct a new needs assessment to drive the type of support the district provides to teachers. Having developed, taught, and evaluated one unit of study in the first year, grade level teams will begin to develop a second unit in a different topic area (for example, in Earth Sciences rather than Life Sciences), and will teach the revised unit from their first year of collaboration.

In this phase, the garden coordinator will continue to support teachers using the native habitat for learning, and will seek sustained funding to support the gardens and garden learning. The coordinator, participating alongside classroom teachers in NGSS training and lesson development, will work to make the garden an integral part of interdisciplinary learning at the two schools. Ongoing professional development for teachers by colleagues who have

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participated in LifeLab or Edible Schoolyard training will help more teachers integrate arts, social studies, and mathematics into their NGSS use of the garden.

Implementation Phase. At this point it is not easy to envision the point at which full implementation will reach this or any district. Over the course of the next several years, the state will finalize its version of the standards, will develop protocols for assessments, and will begin to identify published curriculum that support the NGSS. The district will facilitate the move toward implementation by maintaining support for the lead science teacher team as its members continue to stay abreast of statewide developments and share that information with colleagues. The lead team will continue to advise their colleagues and support them as they continue to explore the standards and create local units of study, eventually heading up the effort to identify, evaluate, and select published science curriculum for grades K-8.

The gardens will be an integral part of NGSS implementation, serving as a focal point in each school for investigations and action projects including scientific experiments, agricultural engineering, environmental stewardship, and health and nutrition efforts. The units of study developed in the Awareness and Transition phases will be archived for teachers to use from year to year. Since teachers will by this time have a high level of awareness and experience with the standards, the district will be in a strong position to evaluate published NGSS curriculum thoughtfully when it becomes available. The lead team will facilitate the decision-making process, helping the district select robust materials that continue to support students in all three dimensions of the NGSS.

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Conclusion

The Next Generation Science Standards present an opportunity to shift elementary science instruction from a text-based model with the teacher at the center of expertise to an experience-based model with the students at the center of investigation and innovation. This is a dramatic change and will require teachers to rethink the way they engage themselves and their students in the practices and concepts of science. Individual districts can move ahead in spreading awareness of the standards, building capacity and enthusiasm among teachers, and providing opportunities and resources to develop and implement quality science experiences at the local level.

Ultimately, the biggest challenge for this and other districts moving into Next Generation Science Standards is to provide strong, supportive leadership. By developing articulated opportunities for teachers to explore, investigate, and apply the standards, district leaders can model the type of teaching demanded by the new science standards, and can help teachers experience the inquiry model as they build a new system of teaching and learning science. By supporting the gardens, the district can ensure that a living laboratory is available to every student as a site for investigation, observation, and action. By creating a core team of science leaders, the district can support peers to help peers develop the skills they need to sustain the effort to innovate in elementary science teaching and learning. In this way, even a small, rural district like this one can bring teachers and students forward into the “having of wonderful ideas” in a thoughtful and exciting way.

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References

- Aschbacher, P., & Alonzo, A. (2006). *Examining the utility of elementary science notebooks for formative assessment purposes*. *Educational Assessment*, 11(3-4), 179-203.
- Baker, D. (2013). *Art Integration and Cognitive Development*. *Journal For Learning Through The Arts*, 9(1).
- Barth, R. S. (1972). *Open Education and the American School*. New York: Agathon Press.
- Bedward, J., Carter, M., Madden, L., Minogue, J., & Wiebe, E. (2010). *Graphically enhanced science notebooks: student-generated graphics provide opportunities for students to express themselves at every stage of an investigation*. *Science and Children*, 48(3), 52.
- Bell, P., Bricker, L., Tzou, C., Lee, T., & Van Horne, K. (2012). Exploring the science Framework: engaging learners in scientific practices related to obtaining, evaluating, and communicating information. *The Science Teacher*, 79(8).
- Biological Sciences Curriculum Study. (2012) *BSCS Middle School Science*. Retrieved from <http://elearn.bscs.org>.
- Bruner, J. (1964). The course of cognitive growth. *American Psychologist*, 19(1), 1-15.
- Bybee, Rodger W. (2013) *Translating the NGSS for classroom instruction*. Arlington, VA: National Science Teachers Association.
- Bybee, Rodger W. (2014). NGSS and the Next Generation of Science Teachers. *Journal of Science Teacher Education*, 25(2), 211-221.
- California Department of Resources Recycling and Recovery (CalRecycle) (2015). *California's Environmental Principles and Concepts*. Retrieved from <http://www.californiaeei.org/>

SCIENCE CURRICULUM - NEXT GENERATION STANDARDS

California Science Teachers Association (2015). *Next Generation Science Standards Timeline*

for New Science Standards for California. Retrieved from

http://www.cascience.org/csta/ngss_timeline.asp

Center for Insect Science Education Outreach (1997). *Using Live Insects in Elementary*

Classrooms for Early Lessons in Life. University of Arizona, retrieved from

<http://insected.arizona.edu/>.

Cutter-Mackenzie, A. (2009). *Multicultural School Gardens: Creating Engaging Garden Spaces*

in Learning about Language, Culture, and Environment. Canadian Journal Of

Environmental Education, 14 (122-135).

Dewey, J (1916). *Democracy and education: An introduction to the philosophy of education*.

New York: Macmillan.

Duckworth, E.R. (2006). *“The Having of Wonderful Ideas” and Other Essays on Teaching and*

Learning. Third edition. New York: Teachers College Press.

Education Development Center (1970). *The ESS Reader*. Newton, Massachusetts: Education

Development Center

Friel, S., Curcio, F., & Bright, G. (2001). *Making Sense of Graphs: Critical Factors Influencing*

Comprehension and Instructional Implications. Journal for Research in Mathematics

Education, 32(2), 124-158.

Full Option Science System (2013). *Standards Alignment*. Retrieved from The Full Option

Science System website at <http://www.fossweb.com>. Gemmill, A. (1949). *Elementary*

science education. Science Education, 33(4), 280-282.

SCIENCE CURRICULUM - NEXT GENERATION STANDARDS

- Griffith, G. & Scharmann, L. (2008). *Initial Impacts of No Child Left Behind on Elementary Science Education*. *Journal of Elementary Science Education*, 20(3), 35-48.
- Jaffe, R., & Appel, G. (2007). *The Growing Classroom: Garden-Based Science*. Burlington, VT: National Gardening Association.
- Klentschy, M. (2008). *Using Science Notebooks in Elementary Classrooms*. Arlington, Virginia: NSTA Press.
- Kneidel, S. (1993). *Creepy Crawlies and the Scientific Method*. Golden, CO: Fulcrum Publishing.
- Krajcik, J. , Codere, S. , Dahsah, C. , Bayer, R. , & Mun, K. (2014). Planning instruction to meet the intent of the next generation science standards. *Journal of Science Teacher Education*, 25(2), 157-175.
- Laws, J., Breunig, E., Lygren, E., and Lopez, C. (2012). *Opening the World through Nature Journaling*. Sacramento: California Native Plant Society.
- Lee, O., Quinn, H., and Valdes, G. (2013). *Science and language for English language learners in relation to next generation science standards and with implications for common core standards for English language arts and mathematics*. *Educational Researcher*, 42(4), 223-233.
- Lockard, J. David, editor (1968). *Sixth Report of the International Clearinghouse on Science and Mathematics Curricular Developments 1968*. College Park, Maryland: Commission on Science Education, American Association for the Advancement of Science

SCIENCE CURRICULUM - NEXT GENERATION STANDARDS

- Lomon, E. L., Beck, B. and Arbetter, C. C. (1975). *Real Problem Solving in USMES: Interdisciplinary Education and Much More*. School Science and Mathematics, 75(1), 53–64.
- Marzano, Robert J. (2011). The Perils and Promises of Discovery Learning. *Educational Leadership* 69 (1), 86-87.
- National Academy of Sciences. (2015). *Requirements of implementing next generation science standards*. Science Daily. Retrieved from <http://www.sciencedaily.com/releases/2015/01/150108130121.htm>
- National Environmental Education Foundation, (2015). *Next Generation Science Standards: The Environment as a Laboratory for Developing Skills in Science and Engineering Practices*. Retrieved from <http://eeweek.org/ee-and-next-generation-science-standards>
- National Governors Association Center for Best Practices & Council of Chief State School Officers (2010). *Common Core State Standards for English Language Arts And Literacy in History/Social Studies, Science, and Technical Subjects*. Washington, DC: Authors.
- National Research Council (2013). *Next Generation Science Standards: For States, By States*. Washington, DC: The National Academies Press.
- National Research Council. (1996). *National Science Education Standards : Observe, Interact, Change, Learn*. Washington, DC: National Academy Press, 1996.
- No Child Left Behind (NCLB) Act of 2001, Pub. L. No. 107-110, § 115, Stat. 1425 (2002).
- Olson, S. & Loucks-Horsley, S. (2000). *Inquiry and the National Science Education Standards: A Guide for Teaching and Learning*. Washington, DC: The National Academies Press.

SCIENCE CURRICULUM - NEXT GENERATION STANDARDS

- Piaget, J. (1964). *Part I: Cognitive development in children: Piaget development and learning*. *Journal of Research in Science Teaching*, 2(3), 176-186.
- Project WET Foundation (2015). *Project WET Curriculum and Activity Guide 2.0: Correlations to National Standards*. Retrieved from <http://www.projectwet.org>.
- Project WILD, Western Association of Fish and Wildlife Agencies (U.S.), & Council for Environmental Education. (2012). *Project WILD: K-12 Curriculum & Activity Guide*. Houston, Tex: Project WILD.
- Project WILD., & Council for Environmental Education. (2013). *Aquatic WILD K-12 Curriculum & Activity Guide*. Houston, TX: Council for Environmental Education.
- Shann, M. (1977). *Evaluation of an interdisciplinary, problem solving curriculum in elementary science and mathematics*. *Science Education*, 61 (4), 491-502.
- Simmons, B. (2010). *Excellence in Environmental Education—Guidelines for Learning (K–12)*. Washington, DC: North American Association for Environmental Education. Retrieved from <http://eelinked.naaee.net/n/guidelines/posts/Excellence-in-Environmental-Education-Guidelines-for-Learning-K-12>
- Stoddart, T., Pinal, A., Latzke, M., and Canaday, D. (2002). *Integrating inquiry science and language development for English language learners*. *Journal of Research in Science Teaching*, 39 (8), 664-687.
- Waters, A. (2008). *Edible Schoolyard*. San Francisco: Chronicle Books.
- Whitacre, P.T. (2014). *NGSS: What Do the New Standards Mean for Environmental Education?* The Branch: Project Learning Tree’s Newsletter, Winter 2014. Retrieved from <https://www.plt.org/newsletter-next-generation-science-and-ee>.

SCIENCE CURRICULUM - NEXT GENERATION STANDARDS

Wilson, C., Taylor, J., Kowalski, S., & Carlson, J. The Relative Effects and Equity of Inquiry-Based and Commonplace Science Teaching on Students' Knowledge, Reasoning, and Argumentation. *Journal of Research in Science Teaching*, 47(3), 276–301.

Zwiers, J., O'Hara, S., & Pritchard, R. *Conversing to Fortify Literacy, Language, and Learning*. *Voices from the Middle*, 22 (1), 10-14.

Appendices

Appendix A: Text of K-8 Science Survey

Please help ASJUSD understand more about science teaching and learning in the K-8 schools!

We are seeking your input on how you teach science now, how you would like to teach science in the future, and what you need to develop a great science classroom. As the district moves toward implementation of the Next Generation Science Standards, your professional opinions and expertise will help shape the best possible science learning opportunities for students.

About You

Tell us a bit about yourself and your science teaching experience.

What topics, themes or units do you teach? List as many as you wish. *(open response)*

What resources do you use in developing science units for your class? *(open response)*

In what grade level(s) do you teach science? * Required. Choose as many grades as you work with in science. Check all that apply.

Checkboxes: Preschool/Kindergarten/1/2/3/4/5/6/7/8/Other:

What field trips, outside speakers, or other extended resources do you use? *(open response)*

What subjects do you currently integrate with science? Check all that apply.

Checkboxes: Mathematics/Language Arts/Social Studies/ELD/Arts/Music/PE/
Technology/Other:

What do you need?

Think ahead to where you'd like to go with science teaching and learning.

Looking forward, what subjects would you like integrate with science? Check all that apply.

Checkboxes: Mathematics/Language Arts/Social Studies/ELD/Arts/Music/PE/
Technology/Other:

SCIENCE CURRICULUM - NEXT GENERATION STANDARDS

What do you know about the Next Generation Science Standards? Mark only one oval.

Checkboxes: Never heard of them/I've heard of them, but haven't seen them/I know about them but haven't used them to design lessons or units/I feel familiar with them and have started using them to design instruction/Other:

What support do you need to align your instruction with the Next Generation Science Standards?

Choose as many as you want! Check all that apply.

Checkboxes: Formal training on the standards/More information in the content areas I need to teach/Online (self-paced) training/Collaboration time to develop curriculum/Internet resources to do my own professional development/A library or resource center/Aligned curriculum package/Teacher-produced units to share/Nothing, I'm all ready to implement/Other:

What other resources do you need for teaching science? Choose as many as you wish you had. Check all that apply.

Checkboxes: New/different curriculum/New/different tools/Nonfiction literature in the classroom/Nonfiction literature in the library/Field trip funds/Science equipment/Coaching in science teaching strategies/Professional development/Schedule changes/Other:

Science in Your Classroom

To what extent do you use experiential inquiry in your science teaching? Mark only one oval. (*Likert scale*)

From 1: Entirely text-based direct instruction
To 10: Entirely experiential inquiry based

—

How confident do you feel about facilitating science conversations in your class? Mark only one oval. (*Likert scale*)

From 1: Not so confident
To 10: Extremely confident

How confident do you feel about designing inquiry science lessons? Mark only one oval. (*Likert scale*)

From 1: Not confident; not sure how to design inquiry science lessons
To 10: 100% certain I can design inquiry science lessons

SCIENCE CURRICULUM - NEXT GENERATION STANDARDS

How confident do you feel about integrating literacy (ELA) into science lessons? Mark only one oval. (*Likert scale*)

From 1: Not so confident
To 10: Extremely confident

How confident do you feel about integrating art into science lessons? Mark only one oval. (*Likert scale*)

From 1: Not so confident
To 10: Extremely confident

How confident do you feel about integrating math into science lessons? Mark only one oval. (*Likert scale*)

From 1: Not so confident
To 10: Extremely confident

Your Students and Science

What have you observed about how your students learn science?

To what extent are your students able to explain what they learn from a science experience? This is your subjective opinion based on observations in your classroom. Mark only one oval. (*Likert scale*)

From 1: Students do not generate original explanations
To 10: Students routinely generate explanations grounded in their experience

To what extent are your students able to interpret mathematical data to draw conclusions in science? This is your subjective opinion based on observations in your classroom. Mark only one oval. (*Likert scale*)

From 1: Students do not analyze data to draw conclusions
To 10: Students fluently examine, analyze, and discuss numerical data in science.

To what extent are your students able to base conclusions on evidence in science? This is your subjective opinion based on observations in your classroom. Mark only one oval. (*Likert scale*)

From 1: Students do not use evidence, or can't state conclusions
To 10: Students effectively use evidence as a foundation for their conclusions

SCIENCE CURRICULUM - NEXT GENERATION STANDARDS

Do you see any obstacles to your students' learning science? (*open response*)

Any other thoughts about how your students learn science? (*open response*)

School Garden and/or Habitat Study Area

What do you think about the school garden for teaching and learning science? (*open response*)

What would it be like to have an onsite or adjacent wetland habitat for students to study? (*open response*)

How do you use the school garden in teaching science (if you do)? (*open response*)

How often do you use the school garden as part of your science curriculum? Mark only one oval.

Checkboxes: Never/A few times a year/At least once a month/At least once a week/Often during a particular unit, but not otherwise/Other:

If you could design the perfect school garden, what would it be like? (*open response*)

What would make the school garden more useful to you for teaching science? (*open response*)

Would you use a local or on site wetland or riparian (creek) restoration project to teach science? This would be a native plant/wildlife area near school or on school grounds. Mark only one oval. (*Likert scale*)

From 1: I wouldn't be likely to use it.
To 10: I would use it all the time!

What would be the ideal local or on site wetland or riparian restoration project for teaching science? Choose as many characteristics as you like, and/or add your own. Check all that apply.

Checkboxes: Small pond/Riparian (seasonal creekbed) adjacent to campus/Trail with interpretation/Micro park off site (public access)/Benches/Tables/Standing water/Damp soils and water-loving plants/Wildlife viewing station/Public (outdoor) art/On campus/Off campus/Other:

Any other thoughts about a wetland/riparian habitat?

Anything Else?

What else would you like to tell us about teaching science in your classroom and school?

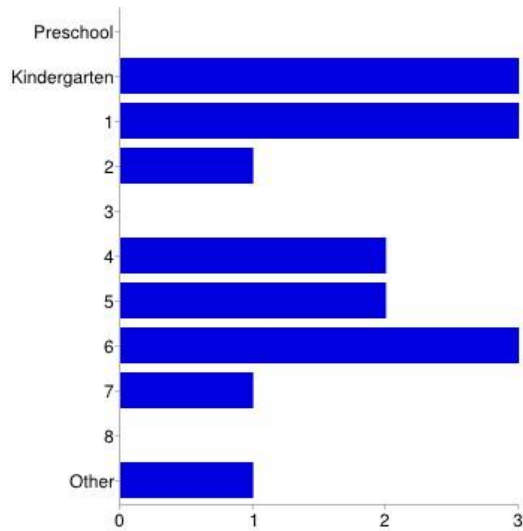


Appendix B: Results of K-8 Science Teacher Survey

Summary - 15 Responses

About You

In what grade level(s) do you teach science?



Grade Level	Count	Percentage
Preschool	0	0%
Kindergarten	3	20%
1	3	20%
2	1	6.7%
3	0	0%
4	2	13.3%
5	2	13.3%
6	3	20%
7	1	6.7%
8	0	0%
Other	1	6.7%

SCIENCE CURRICULUM - NEXT GENERATION STANDARDS

What topics, themes or units do you teach?

Magnetism, Sink/float, five senses, Animals, Lifecycles (butterflies/plants), Landforms, Scientific Process, Habitats

Phonics, reading, writing, math, PE, social studies, life science, physical science, earth science, animals, life cycles, etc.

weather seasons birds mammals amphibians reptiles habitats states of matter plants insects ocean earth day

Rocks Plants, photosynthesis Food Chains, Webs Erosion

English, History

Animals, plants, weather

Animal groups and traits and habitats. Animal, plant, insect and weather cycles Ecology: natural resources and preservation Seasons

Earth Science

Weather, Rainforest (animal habitats, diversity, and extinction), Foods and Nutrition, Planting (soils, seeds etc.) Dental health, Animals in general is big in 1st grade.

Life Science

weather five senses butterfly life cycle chick/egg life cycle sea life plant growth

Electricity, matter, cells, Human body systems, plant structures and

functions, photosynthesis, water cycle, freshwater resources, Ca. water supply,

Atmosphere of Earth, air currents, oceans and air temp., the solar system, elements.

Reading I teach something from all subjects! I have the Garden Club 2xs week

Coastal environment/ ecology Weather/ water cycle human body Plants and photosynthesis

SCIENCE CURRICULUM - NEXT GENERATION STANDARDS

What resources do you use in developing science units for your class?

Text materials

Readworks.org, provides science curriculum, teachers pay teachers, Pinterest, non fiction books that I have bought or checked out from the library, field trips, brain pop videos, you tube videos and any other items I can find!

books, internet, years of accumulating files

Technology Videos Virtual Labs Data Labs Demonstrations

Textbook, personal books I purchased specifically on Science concepts, and internet.

Houghton Mifflin

I do not need to develop units for class. However, when I taught summer school I incorporated microscopes, plants, insects, online insect identification. In everything I do I use realia.

Field trips, speakers, realia, basal text (MacMillan, 2006), videos and on line resources. My own accumulation of curriculum and Houghton Mifflin Science

none

personal materials hands on materials literature field trips variety of older curriculum units/personally adapted to level workbook pages of current curriculum

Science Book Internet Searches BrainPop

Glencoe Earth Science Textbook.

The internet, Common Core Science standards, Brainpop Jr., Science journals, Monterey Bay Aquarium

Classroom text and additional visual handouts. I create appropriate hands-on activities and art when time allows

SCIENCE CURRICULUM - NEXT GENERATION STANDARDS

What field trips, outside speakers, or other extended resources do you use?

Butterflies--Pacific Grove Monarch Butterfly Sanctuary, Monterey Bay Aquarium-
Animals/Oceans

Field trips are becoming a thing of the past with the rising costs, the difficulty of paying (district requirements) and less parent participation. In the past I found the Henry Cowell forest trip and the Sea Cliff state beach to be valuable experiences for my classes. I have also been trained to take students to an exceptional learning trip to Elkhorn Slough. Casa de Fruta is a fabulous learning adventure both in animal study and in social studies.

Santa Cruz County Outdoor Science School.

Field trips: Butterfly sanctuary Monterey Bay Aquarium MY Museum Seacliff Beach
Monterey Bay Aquarium, Elkhorn Slough, Seymour Discovery Center at Long Marine Lab,
UCSC. For studies of the human body, I have obtained animal organs from Doad
Hext (mobile butcher) and Freedom Meat Locker.

Hiking

forest, ocean, wetlands, museums

Elkhorn Slough, Aquarium, Beach trip, are some field trips.

Tech Museum in San Jose

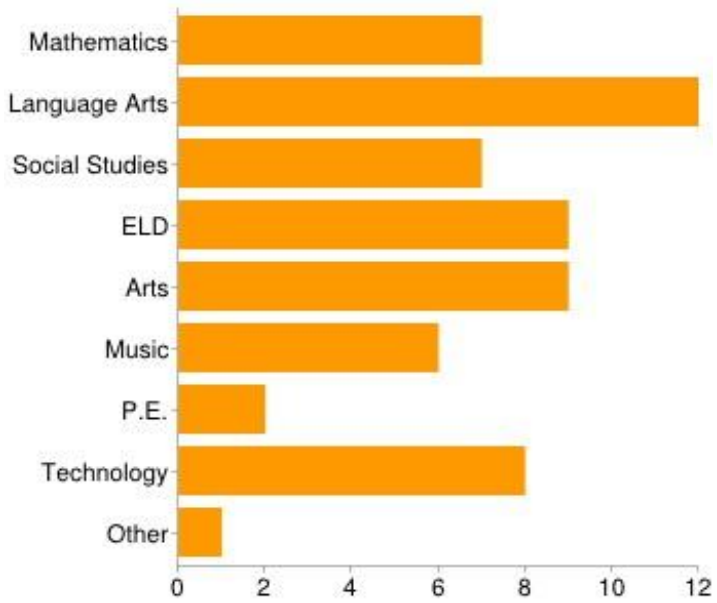
Monterey Bay Aquarium, Henry Cowell State Park, Moss Landing, you tube and brain
pop videos

none

WERC from Morgan Hill, Gilroy Gardens, Visiting dentist from Prune Dale.

SCIENCE CURRICULUM - NEXT GENERATION STANDARDS

What subjects do you currently integrate with science?

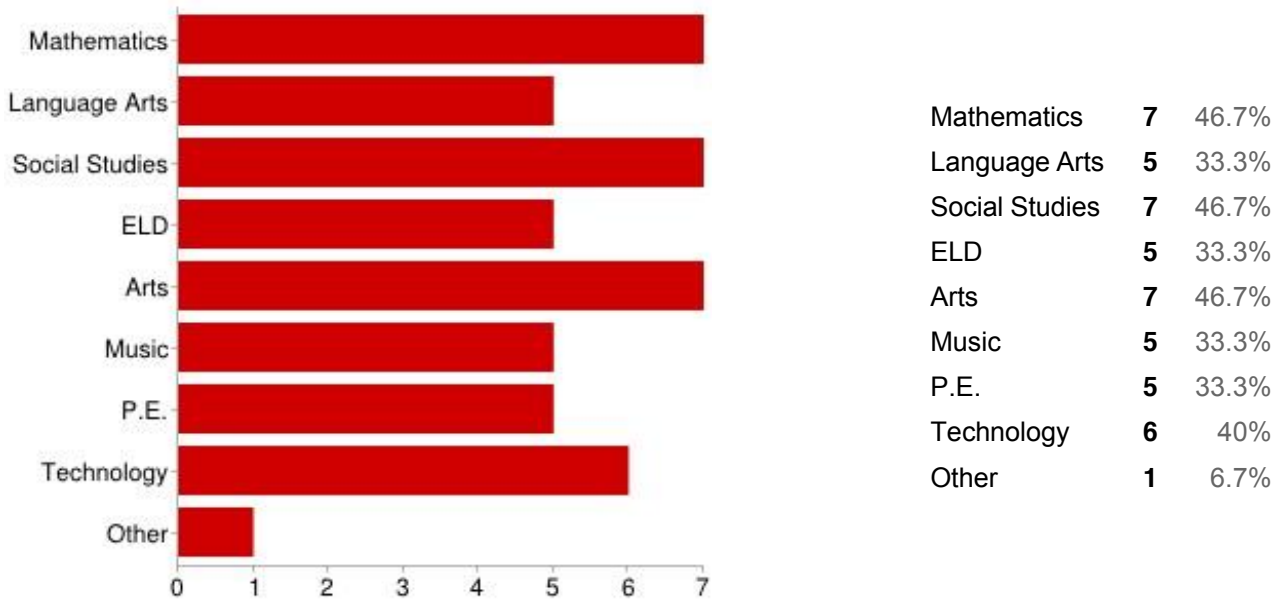


Mathematics	7	46.7%
Language Arts	12	80%
Social Studies	7	46.7%
ELD	9	60%
Arts	9	60%
Music	6	40%
P.E.	2	13.3%
Technology	8	53.3%
Other	1	6.7%

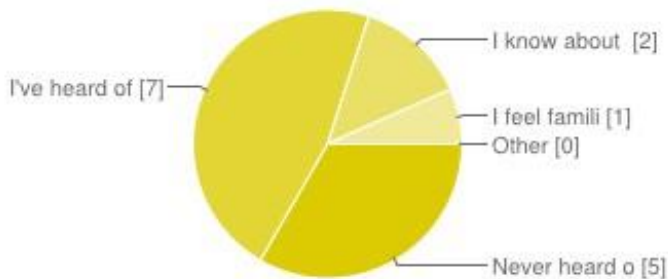
SCIENCE CURRICULUM - NEXT GENERATION STANDARDS

What do you need?

Looking forward, what subjects would you like integrate with science?



What do you know about the Next Generation Science Standards?



Never heard of them	5	33.3%
I've heard of them, but haven't seen them	7	46.7%
I know about them but haven't used them to design lessons or units	2	13.3%
I feel familiar with them and have started using them to design instruction	1	6.7%
Other	0	0%

SCIENCE CURRICULUM - NEXT GENERATION STANDARDS

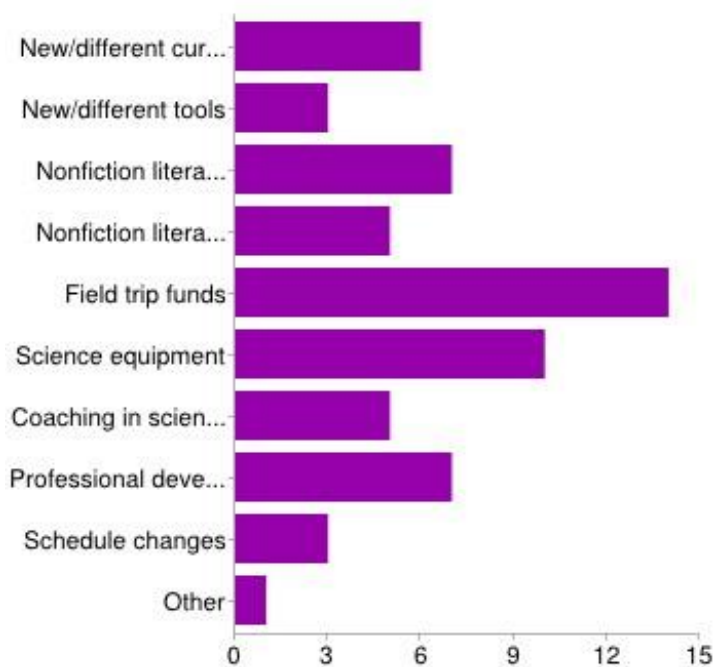
What support do you need to align your instruction with the Next Generation Science Standards?



Formal training on the standards	8	53.3%
More information in the content areas I need to teach	8	53.3%
Online (self-paced) training	4	26.7%
Collaboration time to develop curriculum	8	53.3%
Internet resources to do my own professional development	4	26.7%
A library or resource center	5	33.3%
Aligned curriculum package	6	40%
Teacher-produced units to share	8	53.3%
Nothing, I'm all ready to implement	0	0%
Other	1	6.7%

SCIENCE CURRICULUM - NEXT GENERATION STANDARDS

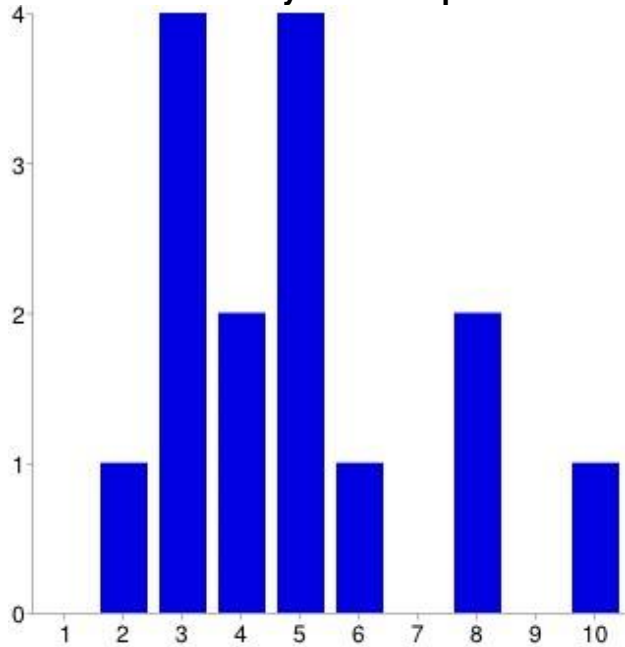
What other resources do you need for teaching science?



New/different curriculum	6	40%
New/different tools	3	20%
Nonfiction literature in the classroom	7	46.7%
Nonfiction literature in the library	5	33.3%
Field trip funds	14	93.3%
Science equipment	10	66.7%
Coaching in science teaching strategies	5	33.3%
Professional development	7	46.7%
Schedule changes	3	20%
Other	1	6.7%

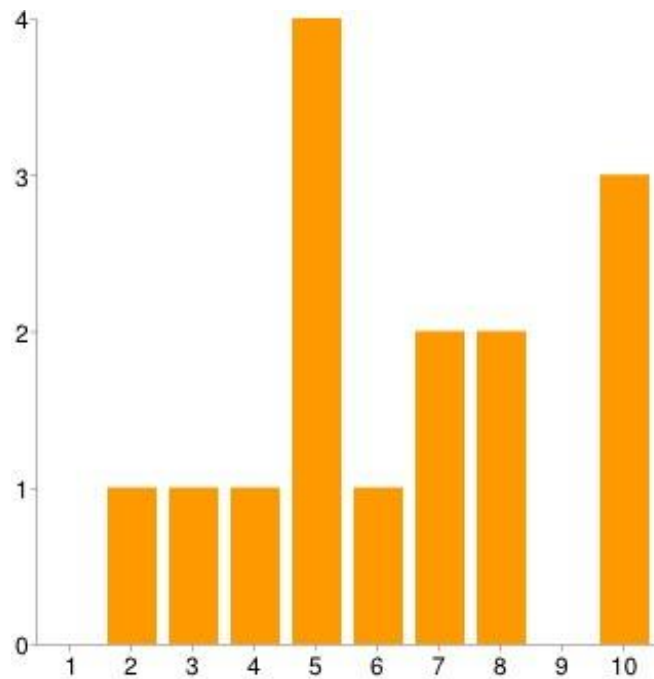
Science in Your Classroom

To what extent do you use experiential inquiry in your science teaching?



1	0	0%
2	1	6.7%
3	4	26.7%
4	2	13.3%
5	4	26.7%
6	1	6.7%
7	0	0%
8	2	13.3%
9	0	0%
10	1	6.7%

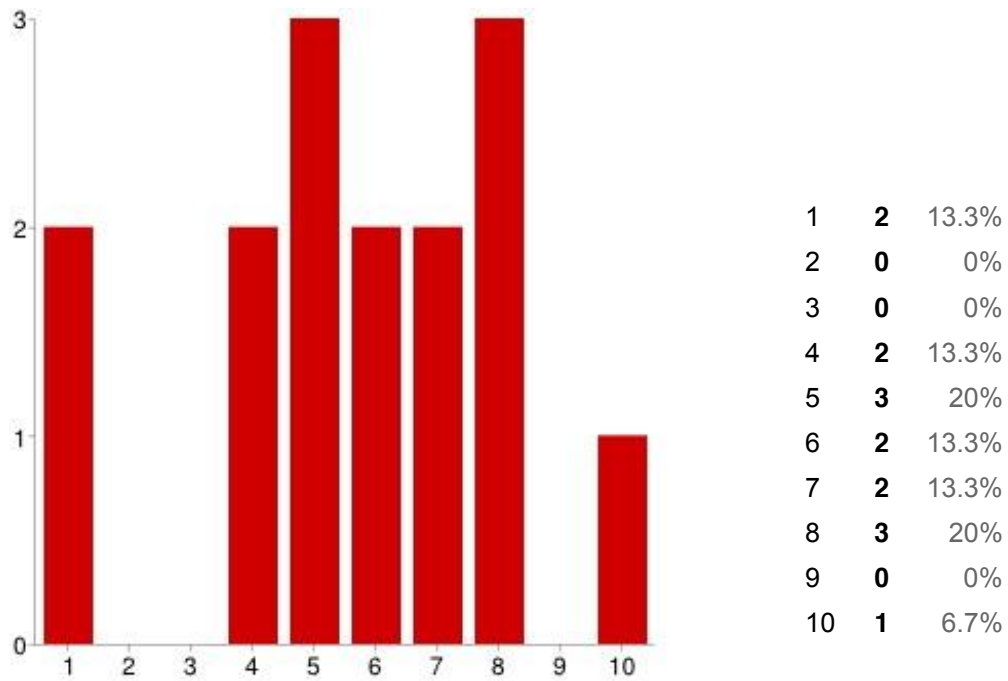
How confident do you feel about facilitating science conversations in your class?



1	0	0%
2	1	6.7%
3	1	6.7%
4	1	6.7%
5	4	26.7%
6	1	6.7%
7	2	13.3%
8	2	13.3%
9	0	0%
10	3	20%

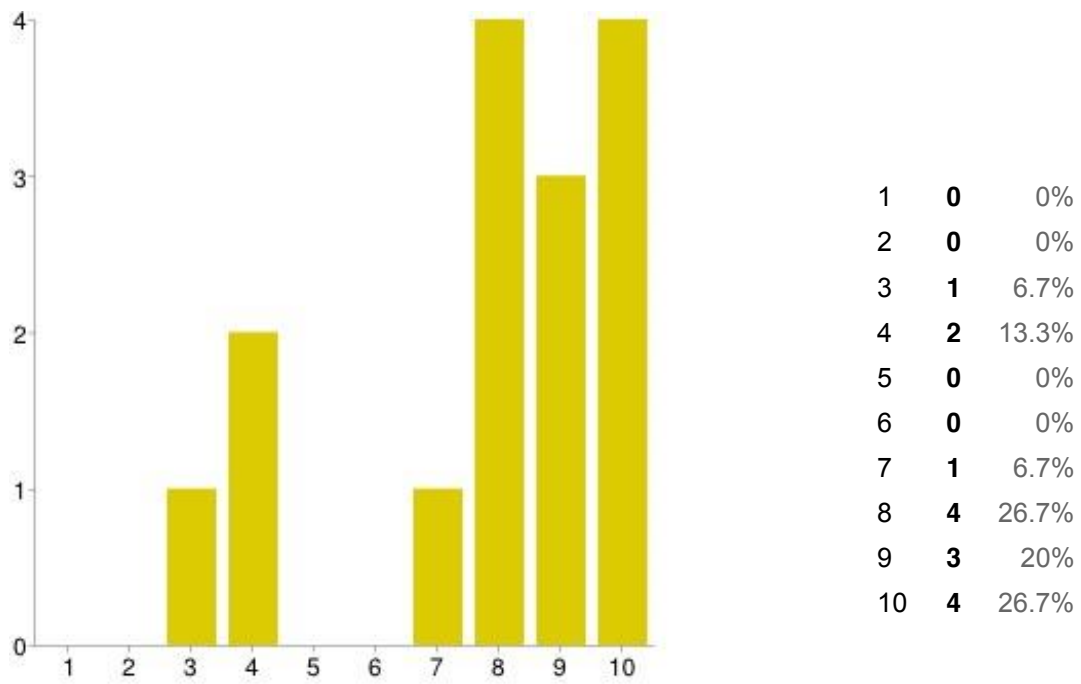
SCIENCE CURRICULUM - NEXT GENERATION STANDARDS

How confident do you feel about designing inquiry science lessons?



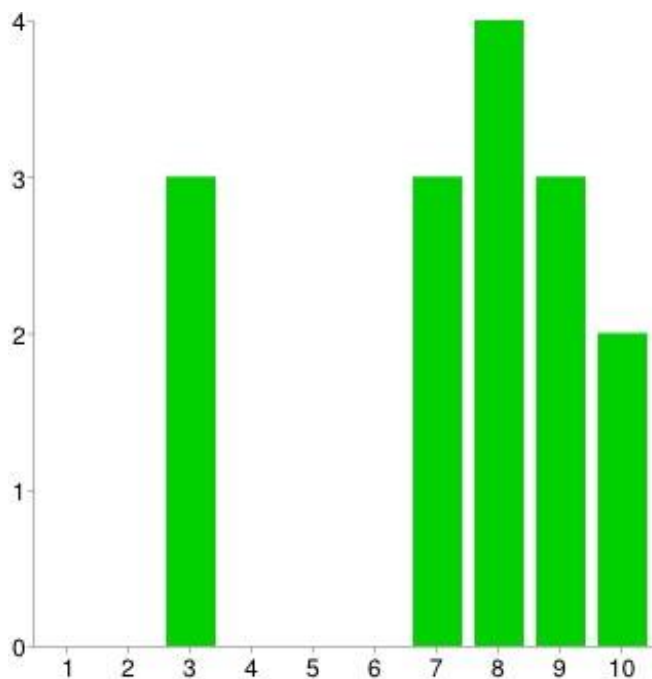
SCIENCE CURRICULUM - NEXT GENERATION STANDARDS

How confident do you feel about integrating literacy (ELA) into science lessons?



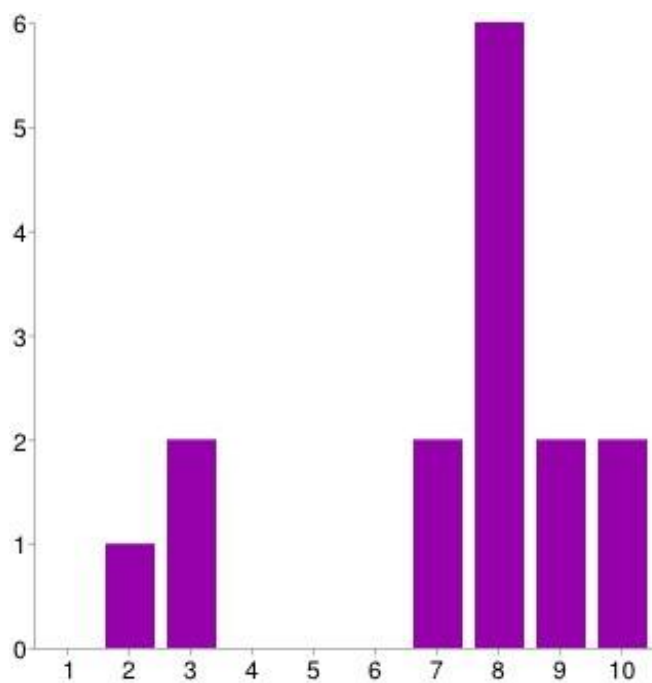
SCIENCE CURRICULUM - NEXT GENERATION STANDARDS

How confident do you feel about integrating art into science lessons?



1	0	0%
2	0	0%
3	3	20%
4	0	0%
5	0	0%
6	0	0%
7	3	20%
8	4	26.7%
9	3	20%
10	2	13.3%

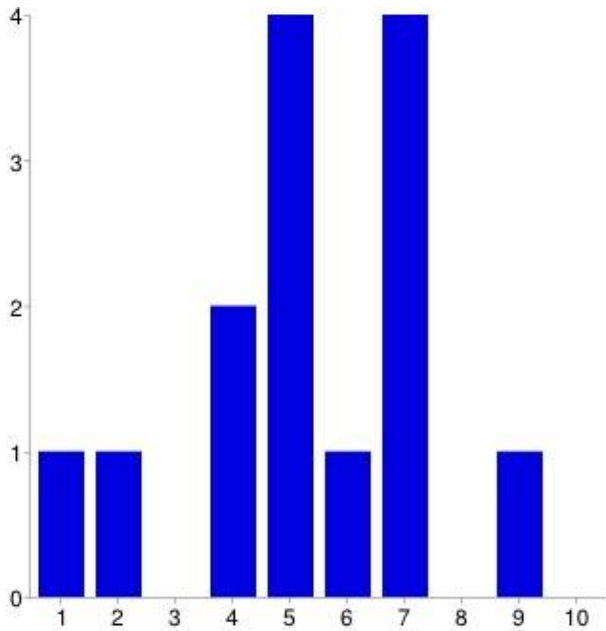
How confident do you feel about integrating math into science lessons?



1	0	0%
2	1	6.7%
3	2	13.3%
4	0	0%
5	0	0%
6	0	0%
7	2	13.3%
8	6	40%
9	2	13.3%
10	2	13.3%

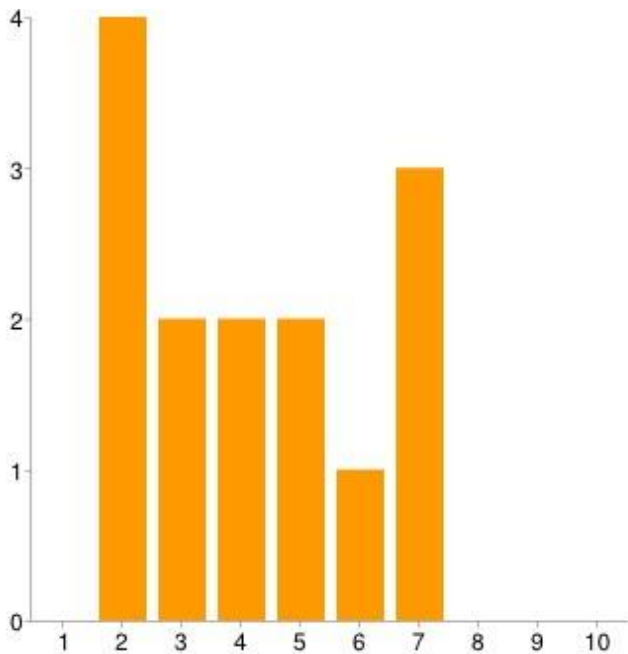
Your Students and Science

To what extent are your students able to explain what they learn from a science experience?



1	1	6.7%
2	1	6.7%
3	0	0%
4	2	13.3%
5	4	26.7%
6	1	6.7%
7	4	26.7%
8	0	0%
9	1	6.7%
10	0	0%

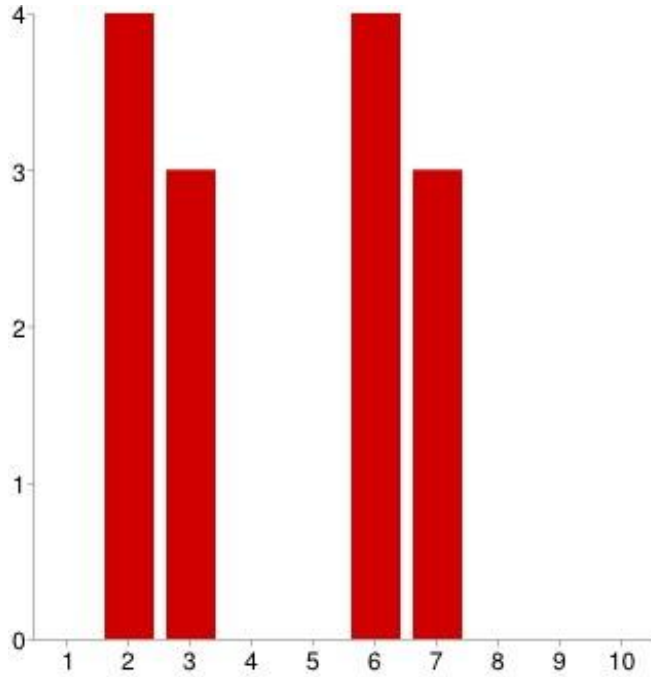
To what extent are your students able to interpret mathematical data to draw conclusions in science?



1	0	0%
2	4	26.7%
3	2	13.3%
4	2	13.3%
5	2	13.3%
6	1	6.7%
7	3	20%
8	0	0%
9	0	0%
10	0	0%

SCIENCE CURRICULUM - NEXT GENERATION STANDARDS

To what extent are your students able to base conclusions on evidence in science?



1	0	0%
2	4	26.7%
3	3	20%
4	0	0%
5	0	0%
6	4	26.7%
7	3	20%
8	0	0%
9	0	0%
10	0	0%

SCIENCE CURRICULUM - NEXT GENERATION STANDARDS

Do you see any obstacles to your students' learning science?

They do not have an adequate grasp on English, either reading or listening, to understand grade level texts or articles on scientific topics. Students are unaccustomed to providing answers that do not come directly from the text. Students have limited ability to read and extract information from texts of any sort.

no

Some students are below grade level in reading and science text can be difficult to comprehend.

At this time, the greatest obstacle is instructional time and institutional priorities. We are just beginning to move from the NCLB model of didactic reading and math instruction/ test score-based assessment of outcomes. To implement effective science instruction is going to take a radical redefinition of what we do in the classroom and how we monitor and assess student outcomes. Instructional leadership is key--we need to redesign what site leaders/ administrators do and how they support and assess teacher performance.

TIME for planning and professional conversations and planning.

experiences

Commitment Desire Time

They do not have strong science backgrounds coming into my class and struggle with a lot of the concepts. I also do not have a lot of science materials to allow me to perform labs and give demonstrations.

Students need hands on time in science with real experiments and tools.

Perhaps lack of experiences based on their young age.

The amount of time that is available for me to give in depth, engaging and powerful science lessons. Also a lack of materials/updated curriculum.

Not enough time in they day with the pressure of the common core standards, even considering integration with language arts/math. In math, so many concepts in kinder have to be taught explicitly that it is challenging to integrate other things that might distract a five year old from the focus on the main idea you are trying to help them grasp.

SCIENCE CURRICULUM - NEXT GENERATION STANDARDS

Any other thoughts about how your students learn science?

hands on

Think hands on is the best way to learn for the students, but do not always have the time to design a lesson and get all the materials ready. The cost can be prohibitive.

I love science and would like the opportunity for my students to have WAY more exposure to science on a daily basis.

Would love more hands on materials to help them engage with science in a fun and meaningful way.

Hands-on demonstrations and experiments

My students love science, and we have had the great good fortune to do a lot of outdoor observation, informational inquiry and experience this year. We have observed scientists in the field, and interviewed them about what they do. What we have not done so much is setting up our own science investigation model--hypothesizing, observing and drawing conclusions. I would like to do more of the latter.

Many come from a home where there is already a strong interest in a variety of science subjects indicated by their verbal information.

Excellent and effective science instruction is enhanced with whole-school involvement and discussions and leadership.

When they have a topic to investigate or experience it through a field trip they will remember what they did. It will stay with them when they have experienced it. Some teachers have chicken incubators, plants experiments or mice breeding experiments. Those experiences are very powerful. They also help students to look forward to their classroom so they can see how the project/experiment changes on a daily basis. During garden club some students have the freedom to explore what they want and try out new ideas. Our students need that freedom and exploration to be balanced learners.

School Garden and/or Habitat Study Area

How do you use the school garden in teaching science (if you do)?

We do the following: starting plants from seed, making signs for plants growing in the garden, using recyclable materials for pots etc, harvesting seeds and how to store them, experimenting starting seeds with different methods, weeding, composting vegetable waste from the cafeteria, how to water properly, working as a team , planning the garden ordering seeds. Writing letters to as groups in the community.

We do not use it.

NA

I don't use the garden.

At this time, very little. We have observed plant and insect species, life cycles, but have not created or followed through on a specific project.

We have one but I have not been using it, Its the time again.

In the fall with planting of bulbs. In the spring with watching the growth of a seed.

don't any more, need aides

I do not use the school garden

We just planted Easter grass. I just donated organic plants for the garden. I

have not used it this year.

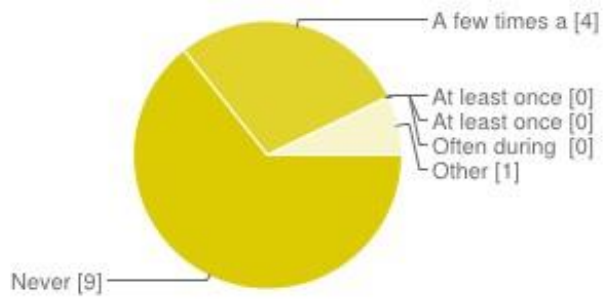
Earth Science? I don't use the garden.

We plant our own seeds in cups for each student during our plant life cycle unit, but I would love to use the school garden more.

It is not a topic of discussion or a value focused on by leadership so is not on the radar for school culture and practice.

SCIENCE CURRICULUM - NEXT GENERATION STANDARDS

How often do you use the school garden as part of your science curriculum?



Never	9	60%
A few times a year	4	26.7%
At least once a month	0	0%
At least once a week	0	0%
Often during a particular unit, but not otherwise	0	0%
Other	1	6.7%

SCIENCE CURRICULUM - NEXT GENERATION STANDARDS

If you could design the perfect school garden, what would it be like?

It would have vegetables and different types of plants

Each class would have their own box.

no comment

Leadership would be the first step to say this was a focus for our school vision and ask us to implement it into our curriculum. It has been many years since Life Lab and Lasers were emphasized in the district. it would take a collaborative effort to get the ball rolling, beginning with administration.

It would be rather big and full of vegetables, fruits, plants and flowers.

I have used a school garden in the past. It was helpful to have a designated class space, and access to garden and science tools that were kept stocked and in an orderly fashion. All teachers were informed of the system, and were held accountable for keeping materials in order and arranging for restocking of used items. There was also a designated science resource person (LASERS grant).

Native plants

hire aides, put in tables, have resources

Higher raised beds, more tables with umbrellas for students to have a class in the garden, fruit trees, succulent area of the garden, better watering system. It should be easy to bring their students into the garden classroom. That it is integrated into their curriculum at least once per year.

Lots of room, raised beds, water, equipment

Grow fruits and veggies that students could plant, care for, and then eat. Also have a section designated for each class.

Not sure

SCIENCE CURRICULUM - NEXT GENERATION STANDARDS

What would make the school garden more useful to you for teaching science?

Time to prep, develop and implement lessons

Every thing needed, such as tools, and seeds, or plants.

If there were more ways to integrate my earth science curriculum into a more life science type of resource.

See above.

Tables

no comment

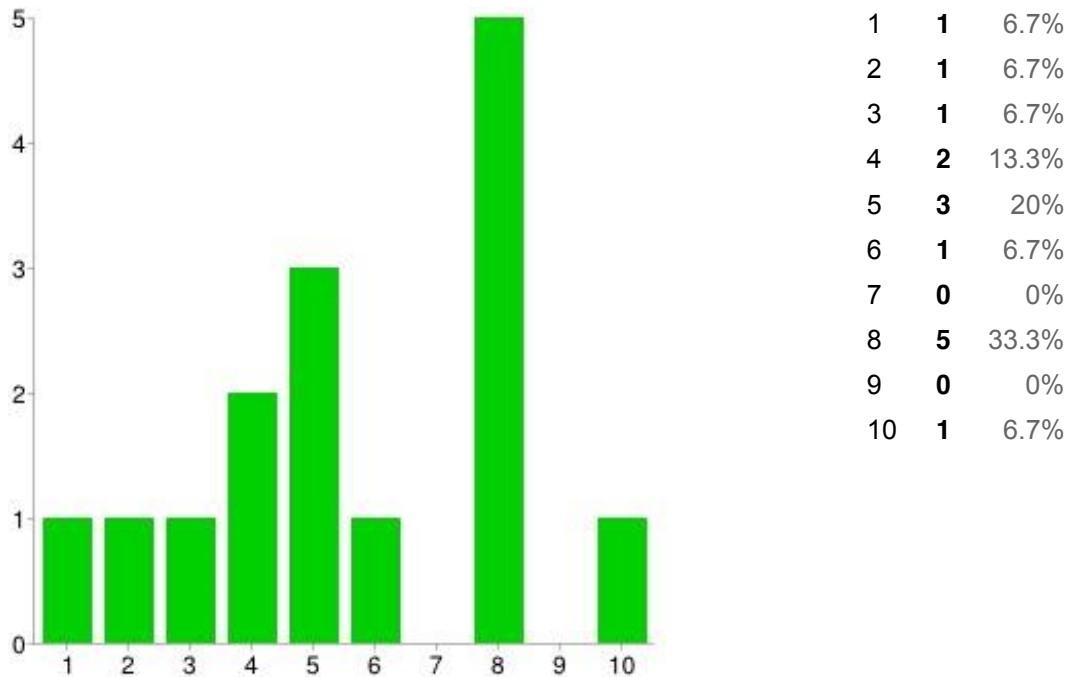
small groups work well

I did take my class to work there last year. I was disappointed to see the efforts we made many years ago were lost. The shed was a mess and all the soil turning tools and trowels were gone. Replacing those so students can prepare the beds would be important.

Not sure. A working hose with key

This would help for lessons on plants.

Would you use a local or on site wetland or riparian (creek) restoration project to teach science?



SCIENCE CURRICULUM - NEXT GENERATION STANDARDS

What would be the ideal local or on site wetland or riparian restoration project for teaching science?

Small pond	10	66.7%
Riparian (seasonal creekbed) adjacent to campus	6	40%
Trail with interpretation	4	26.7%
Micro park off site (public access)	2	13.3%
Benches	7	46.7%
Tables	9	60%
Standing water	1	6.7%
Damp soils and water-loving plants	7	46.7%
Wildlife viewing station	6	40%
Public (outdoor) art	3	20%
On campus	9	60%
Off campus	5	33.3%
Other	0	0%

Any other thoughts about a wetland/riparian habitat?

I don't think we have anything like that nearby. There is a creek near the tracks but I think it has a bad odor or something.

Not really sure how realistic it is but would love it if it happens.

Many years ago we had whole school themes around the Pajaro River and the plants and animal habitat there. I took my class on frequent walks to the river from class, it was an amazing teaching/learning opportunity that expanded and integrated the curriculum throughout the year.

The Pajaro River project that was used many years ago.

Not sure how effective this will be

Anything Else?

What else would you like to tell us about teaching science in your classroom and school?

It is one of the best ways to motivate students to learn. They love to get out of the classroom, and they love science topics. They truly fascinate them.

It doesn't feel valued or appreciated by staff or administration.

-

I need more time, supplies, and training

Would love to have more guest speakers/teachers who could come in and bring their science expertise to the students first hand but I'm not sure where to find the resources/people for this. Need more materials (kid friendly magnets, etc.)

My students have loved investigating and learning about otters and their role in the trophic cascade, which drove a class writing project.

Appendix C: NGSS Performance Expectation

3-LS4-3 Biological Evolution: Unity and Diversity		
<p>Students who demonstrate understanding can:</p> <p>3-LS4-3. Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all. [Clarification Statement: Examples of evidence could include needs and characteristics of the organisms and habitats involved. The organisms and their habitat make up a system in which the parts depend on each other.]</p>		
<p>The performance expectation above was developed using the following elements from the NRC document <i>A Framework for K-12 Science Education</i>:</p>		
<p>Science and Engineering Practices</p>	<p>Disciplinary Core Ideas</p>	<p>Crosscutting Concepts</p>
<p>Engaging in Argument from Evidence</p> <p>Engaging in argument from evidence in 3-5 builds on K-2 experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world(s).</p> <ul style="list-style-type: none"> Construct an argument with evidence. 	<p>LS4.C: Adaptation</p> <ul style="list-style-type: none"> For any particular environment, some kinds of organisms survive well, some survive less well, and some cannot survive at all. 	<p>Cause and Effect</p> <ul style="list-style-type: none"> Cause and effect relationships are routinely identified and used to explain change.
<p>Connections to other DCIs in third grade: 3.ESS2.D</p>		
<p>Articulation of DCIs across grade-levels: KL.ESS3.A ; 2.LS2.A ; 2.LS4.D ; MS.LS2.A ; MS.LS4.B ; MS.LS4.C ; MS.ESS1.C</p>		
<p>Common Core State Standards Connections:</p>		
<p>ELA/Literacy —</p> <p>RI.3.1 Ask and answer questions to demonstrate understanding of a text; referring explicitly to the text as the basis for the answers. (3-LS4-3)</p> <p>RI.3.2 Determine the main idea of a text; recount the key details and explain how they support the main idea. (3-LS4-3)</p> <p>RI.3.3 Describe the relationship between a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text, using language that pertains to time, sequence, and cause/effect. (3-LS4-3)</p> <p>W.3.1 Write opinion pieces on topics or texts, supporting a point of view with reasons. (3-LS4-3)</p> <p>W.3.2 Write informative/explanatory texts to examine a topic and convey ideas and information clearly. (3-LS4-3)</p> <p>SL.3.4 Report on a topic or text, tell a story, or recount an experience with appropriate facts and relevant, descriptive details, speaking clearly at an understandable pace. (3-LS4-3)</p>		
<p>Mathematics —</p> <p>MP.2 Reason abstractly and quantitatively. (3-LS4-3)</p> <p>3.MD.B.3 Draw a scaled picture graph and a scaled bar graph to represent a data set with several categories. Solve one- and two-step "how many more" and "how many less" problems using information presented in scaled bar graphs. (3-LS4-3)</p>		
<p>* The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.</p>		
<p>The section entitled "Disciplinary Core Ideas" is reproduced verbatim from <i>A Framework for K-12 Science Education: Practices, Cross-Cutting Concepts, and Core Ideas</i>. Integrated and reprinted with permission from the National Academy of Sciences.</p>		

Appendix D: Workshop Materials

Next Generation Science Standards in the Garden: An Introduction to Possibilities

This one-day workshop introduces teachers to the structure of the Next Generation Science Standards, the 5E instructional design model, and three instructional practices: sketching from nature, the I² data analysis strategy, and science talks as a way to structure classroom discourse. The workshop includes a series of lessons to demonstrate these concepts and techniques as teachers participate both as observers and as learners in the activities.

Location: TBD

Date: TBD

Time: 9:00 – 3:00

For: K-8 teachers

Benefits: Lesson packet with student handouts
Resource list
Lunch
Door prizes
Stipend/classroom supply grant
CEUs

Habitat by Design

An Investigation into Adaptation and Environment

The garden is a habitat—a place where plants and animals live. In this series of lessons, students consider how animals are adapted to different micro-habitats within the garden. Compost bins, garden boxes, rocky pathways, trees and bushes: for inhabitants as small as worms, ants, roly-polies, snails and earwigs, each of these is a distinct habitat within the world of the garden.

Students:

- explore the ideas of habitat and adaptation in order to...
- collect garden fauna in order to...
- examine and observe one species in detail and go on to...
- graph the attributes of the micro-habitat where it was found, then...
- evaluate this evidence along with text references in order to...
- design an artificial habitat that meets the animal's needs

This unit is based on lessons from Creepy Crawlies and the Scientific Method (Kneidel, 1993), Opening the World through Nature Journaling (Laws, Bruenig, Lygren, and Lopez, 2012), and The Growing Classroom (Jaffe & Appel, 2007). It has been adapted to incorporate the Next Generation Science Standards (National Research Council, 2013), and California's Environmental Concepts and Principles (CalRecycle 2015). Text references about common garden invertebrates came from the Center for Insect Science Education Outreach at the University of Arizona (Center for Insect Science Education Outreach, 1997). The lesson sequence follows the 5E model (Bybee, 2013), which frames the entire set of lessons as an integrated investigation and design problem related to the relationship of habitat and adaptation. It is abbreviated for purposes of a teacher workshop; in a real classroom this unit might reach a performance expectation like this over the course of several weeks rather than several hours.

Anatomy of a Next Generation Science Standard

3-LS4-3 Biological Evolution: Unity and Diversity Title

Students who demonstrate understanding can:

3-LS4-3. Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all. [Clarification Statement: Examples of evidence could include needs and characteristics of the organisms and habitats involved. The organisms and their habitat make up a system in which the parts depend on each other.]

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

<p>Engaging in Argument from Evidence Engaging in argument from evidence in 3–5 builds on K–2 experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world(s). Construct an argument with evidence.</p>	<p>LS4.C: Adaptation • For any particular environment, some kinds of organisms survive well, some survive less well, and some cannot survive at all.</p>	<p>Cause and Effect • Cause and effect relationships are routinely identified and used to explain change.</p>
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Science and Engineering Practice

Disciplinary Core Idea

Cross Cutting Concept

Connections to other DCIs in third grade:
3.ESS2.D

Articulation of DCIs across grade-levels:
K.ESS3.A ; 2.LS2.A ; 2.LS4.D ; MS.LS2.A ; MS.LS4.B ; MS.LS4.C ; MS.ESS1.C

Common Core State Standards Connections:

ELA/Literacy —

RI.3.1 Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers. (3-LS4-3)

RI.3.2 Determine the main idea of a text; recount the key details and explain how they support the main idea. (3-LS4-3)

RI.3.3 Describe the relationship between a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text, using language that pertains to time, sequence, and cause/effect. (3-LS4-3)

W.3.1 Write opinion pieces on topics or texts, supporting a point of view with reasons. (3-LS4-3)

W.3.2 Write informative/explanatory texts to examine a topic and convey ideas and information clearly. (3-LS4-3)

SL.3.4 Report on a topic or text, tell a story, or recount an experience with appropriate facts and relevant, descriptive details, speaking clearly at an understandable pace. (3-LS4-3)

Mathematics —

MP.2 Reason abstractly and quantitatively. (3-LS4-3)

3.MD.B.3 Draw a scaled picture graph and a scaled bar graph to represent a data set with several categories. Solve one- and two-step "how many more" and "how many less" problems using information presented in scaled bar graphs. (3-LS4-3)

Performance Expectation

Related Disciplinary Core Ideas

Common Core Connections

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Definitions

Framework

The National Research Council (NRC) of the National Academy of Sciences managed the first of two steps in the creation of the *Next Generation Science Standards* by developing the A Framework for K-12 Science Education, which was released July 2011.

Performance Expectation

Performance expectations are the assessable statements of what students should know and be able to do. Some states consider these performance expectations alone to be "the standards," while other states also include the content of the three foundation boxes and connections to be included in "the standard." The writing team is neutral on that issue. The essential point is that all students should be held accountable for demonstrating their achievement of all performance expectations, which are written to allow for multiple means of assessment. Most of the performance expectations are followed by one or two additional statements in smaller type. These include clarification statements, which supply examples or additional clarification to the performance expectations; and assessment boundary statements, which specify the limits to large scale assessment.

Scientific and Engineering Practices (Dimension 1)

The practices describe behaviors that scientists engage in as they investigate and build models and theories about the natural world and the key set of engineering practices that engineers use as they design and build models and systems. The NRC uses the term practices instead of a term like "skills" to emphasize that engaging in scientific investigation requires not only skill but also knowledge that is specific to each practice. Part of the NRC's intent is to better explain and extend what is meant by "inquiry" in science and the range of cognitive, social, and physical practices that it requires.

Cross Cutting Concept (Dimension 2)

Crosscutting concepts have application across all domains of science. As such, they are a way of linking the different domains of science. They include: Patterns, similarity, and diversity; Cause and effect; Scale, proportion and quantity; Systems and system models; Energy and matter; Structure and function; Stability and change. The Framework emphasizes that these concepts need to be made explicit for students because they provide an organizational schema for interrelating knowledge from various science fields into a coherent and scientifically-based view of the world.

Disciplinary Core Idea (Dimension 3)

Disciplinary core ideas have the power to focus K–12 science curriculum, instruction and assessments on the most important aspects of science. To be considered core, the ideas should meet at least two of the following criteria and ideally all four:

- Have **broad importance** across multiple sciences or engineering disciplines or be a **key organizing concept** of a single discipline;
- Provide a **key tool** for understanding or investigating more complex ideas and solving problems;

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Relate to the **interests and life experiences of students** or be connected to **societal or personal concerns** that require scientific or technological knowledge;

Be **teachable** and **learnable** over multiple grades at increasing levels of depth and sophistication.

Disciplinary ideas are grouped in four domains: the physical sciences; the life sciences; the earth and space sciences; and engineering, technology and applications of science.

Sources for definitions:

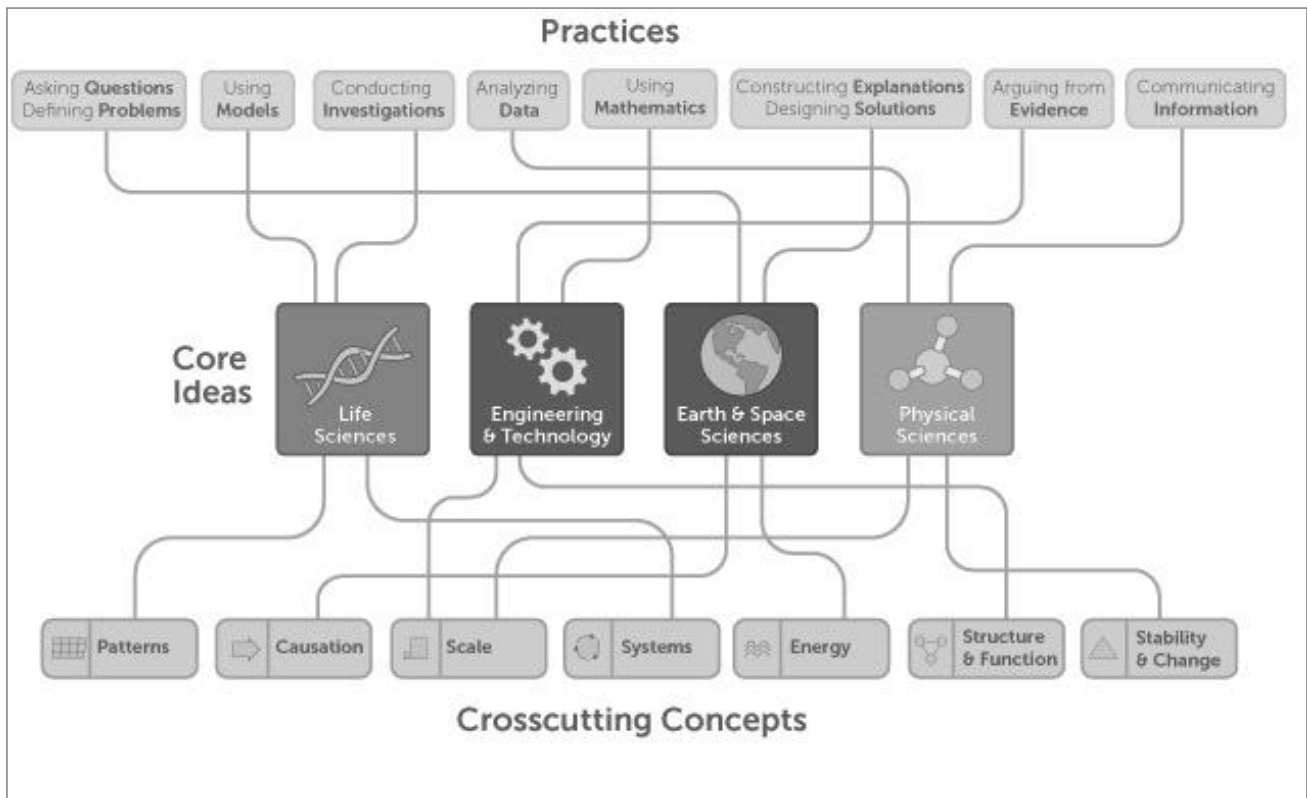
National Science Teachers Association website for NGSS

<http://ngss.nsta.org/>

Next Generation Science Standards website

<http://www.nextgenscience.org/>

Three Dimensions of the NGSS



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As we go through the lesson sequence, mark up your lesson plan and/or this chart when you find evidence of NGSS and CCSS connections.

5E Phase	Title	NGSS DCI	NGSS SEP	NGSS CCC	CCSS
Engage	Imagining Habitat				
Explore	Field Collecting				
Explain	Draw and Observe Up Close				
Elaborate	Analyze Data to Support Habitat Design				
Evaluate	Create a Habitat				

Engage: activate prior knowledge, make connections to past learning experiences, anticipate activities and focus student thinking on the learning outcomes of the unit.

Imagining Habitat

Summary:

The teacher opens a conversation about habitat and elicits the idea that a habitat is where plants and animals live.

Materials needed:

Flipcharts and markers

What happens:

The teacher asks students what they know about habitat. Students are likely to think of distant, exotic habitats: rainforest, desert, kelp forest. Redirecting to considering the school garden as a habitat, the teacher records on flip charts student responses to the following prompts:

What animals have you seen—or might you find--in the garden?

Where in the garden would you look for them?

If we wanted to observe these animals in our classroom for a few weeks, how could we design a space where they could live? (Note: this design problem is the culmination of this mini-unit.)

Closure: Take a few quiet minutes allowing students to imagine all the animals out in the garden **habitat** as the class prepares to go out to the garden.

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5E NOTES: Look in this lesson for ways the students ENGAGE with the content:

NGSS NOTES: Look in this lesson for opportunities to practice or reach the following NGSS dimensions

Science and Engineering Practices:	Evidence you notice
#1 Asking questions, defining problems	

Disciplinary Core Ideas:	Evidence you notice
For any given habitat, some organisms will survive well, some will survive less well, and some will not survive at all.	

Cross-Cutting Concepts:	Evidence you notice
#4 Systems and System Models: A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.	

CCSS Links:	Evidence you notice
Math	
ELA	

Explore: provide a common base of experiences within which they identify and develop science ideas, actively exploring the context.

Field Collecting

Based on LifeLab “Garden Creatures” lesson: Who Lives Here? (Jaffe & Appel, 2007)

Summary:

The teacher accompanies students on a field trip to the garden to locate, record, and collect garden animals. Before leaving, the teacher helps students understand the task of keeping field notes and of careful collecting.

Materials needed:

- Collecting boxes (yogurt tubs with holes punched in the lids)
- Small, moistened cubes of dish sponge to keep animals hydrated in the field
- Tweezers
- Index cards for picking up animals
- Insect nets
- Trowels (for digging in soil or compost)

What happens:

First, the teacher introduces the activity as a field trip, or expedition, into a **habitat** where students will be able to find out where some animals prefer to live in the garden. This is an investigation—the teacher clarifies that an investigation is a search for information, and in this case they are searching for information about **adaptations--** structures and behaviors that help the animals survive-- and **habitat**. The teacher invites students to plan some ways to investigate garden animals, their habitat, and their adaptations; some possibilities include:

- Move quietly
- Collect animals carefully
- Observe thoughtfully
- Record information accurately

Data recording:

Students will record qualities of the microhabitat where they find each animal. For this activity, the students will use hand touch as a way to assess temperature and humidity, and a visual sort to assess exposure. A powerful way to introduce this activity is to have a class discussion to agree on operational definitions of cool, warm and hot and of wet, moist, and dry. This could be an entire class period with students feeling prepared soil samples to decide how they will assess them in the field. A shortcut is to provide the definitions for them, for example:

- Cool means it feels colder than your hand
- Warm means it feels the same as your hand

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- Hot means it feels hotter than your hand
- Wet means it turns your hand wet
- Moist means it feels wet but no water ends up on your hand
- Dry means it makes your hand feel dry or dusty
- Covered means the habitat was underneath something else
- Shady means it was exposed to air but shaded from the sun
- Sunny means the sun was touching the habitat

Observing: Students will collect animals in the microhabitats of the garden: compost pile, garden bed, pathway, shrub, tree, grassy area, leaf litter. Because they will be analyzing the attributes of the habitat the animals prefer and connecting it to the adaptations of the animals that live there, they will need to record details about where they find the animals. Animals usually easy to find in the average school garden include garden snails, roly-polies, ants, earwigs, earthworms, slugs, aphids, and lady beetles (ladybugs). In addition, students should plan to quietly observe the animals' behavior before collecting them, if possible. Some things to notice and note on the field note sheet:

- How does the animal move?
- Where is it going?
- Is it eating anything, and if so, what?

Collecting: Before leaving for the garden, the teacher will:

- Demonstrate how to collect animals, scoop them up gently using the lid of the collecting box, and tap them into the box.
- Demonstrate gentle use of insect net: sweep the net through vegetation, then fold the net across the rim; shake animals to the bottom and grab net above them; turn the net inside out to release them into the cup.
- Show how to use tweezers or a small stick to gently move animals (rather than fingers)
- Remind students to keep the animals in their collecting box in shade.
- If students overturn a rock, log, or other object to find animals underneath, they should be sure to replace it.
- Show students how to record the location and its attributes on the field note page at the time of collection.
- After collecting up to six animals return to the meeting place.

Garden guidelines: Each school garden has its own set of behavioral expectations, but here are few that will be handy when trying to find and observe animals:

1. Walk slowly, only in pathways.
2. Use a gentle touch (leave plants alone for this activity).
3. Use tools wisely.

After spending 15-20 minutes, or when everyone has five animals in their box, return to the classroom or to outdoor tables.

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Closure: The teacher gathers students together to share what they saw.

- How did the investigation compare to the plan?
- Were the animals in places you expected?
- Were there surprises?
- Did you find different kinds of animals in different places?
- What did you notice about the animals in the different places they looked?
- What would you do differently if you did another garden expedition?

The teacher invites students to select just one animal to study up close in the next activity, and lists their choice on a flipchart. It's best to have students working with as many different species as have been collected.

SCIENCE CURRICULUM - NEXT GENERATION STANDARDS

5E NOTES: Look in this lesson for ways the students EXPLORE the content:

NGSS NOTES: Look in this lesson for opportunities to practice or reach the following NGSS dimensions

Science and Engineering Practices:	Evidence you notice
#3 Planning and Carrying Out Investigations	

Disciplinary Core Ideas:	Evidence you notice
For any given habitat, some organisms will survive well, some will survive less well, and some will not survive at all.	

Cross-Cutting Concepts:	Evidence you notice
#1 Patterns. Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.	

CCSS Links:	Evidence you notice
Math	
ELA	

Explain: Develop explanations for the concepts and practices students have been exploring. Verbalize (and in this case also visualize) conceptual understanding.

Drawing and Observing Up Close

Based on California Native Plant Society Opening the World Through Nature Journaling Diagramming activity (Laws, Breunig, Lygren, & Lopez, 2012).

Summary:

In this activity, students investigate their study specimens by looking closely, drawing them in detail, and inferring what physical and behavioral adaptations enable them to live in the microhabitats where they were found in the garden. This activity can take place in the garden or in the classroom, using clear plastic cups as observing chambers.

Materials needed:

- Handlenses
- Sharpened pencils and handheld sharpener
- Small metric rulers
- Field clipboards if working outdoors
- Drawing paper, half sheets (art paper is better than copy paper)
- Clear plastic drink cups or bug boxes
- Tweezers
- Color pencils (optional)
- Discovery Scope (optional)

What happens:

The teacher opens the activity by reminding students that they are researching ways to meet the needs of their study animals by creating an artificial habitat in the classroom. The diagram activity will help them observe and record the animals' **adaptations**—physical characteristics and behaviors that help them survive in their own **habitat**.

Science Talk: In a brief (about 10 minutes) discussion, each student contributes an idea and then calls on another student to continue the conversation. The class discusses the connection between habitat and adaptation based on the animals they've observed and collected. The teacher frames the discussion around the idea of connecting animal and place with evidence: "What did you notice about each animal that helped it survive in the place you found it?" A sentence frame may help English learners formulate contributions: "I found a ____ living in the _____. It can survive there because it has _____" Once the Science Talk gets rolling, the teacher should only intervene if the conversation veers off track, or if it is time to move on to the rest of the activity.

SCIENCE CURRICULUM - NEXT GENERATION STANDARDS

Sketching guidelines: The teacher demonstrates the sketching technique outlined on the student page. It's important—especially with students who are insecure about their drawing skills—to stress that field sketching is a way to record information for science, not a pretty picture for a wall! Scientists care more about true detail than esthetics in their diagrams. Measuring, counting, and labeling are more important than coloring or even neatness. Practice, the repeated work of trying to draw, is the way to train the brain and hand to record nature on a page.

Show students how to

- record overall shape—fill the page
- draw sample details instead of every detail
- show relationships between parts
- count and/or measure parts
- label the diagram with ideas about body structures and behaviors.

Students working with arthropods may wish to refer to the LifeLab diagram of insect body parts or the CISEO information sheet on arthropod body parts as they label their diagram.

The teacher circulates, continually refocusing students on observing and recording how the animal's adaptations (body parts and behaviors) might help it survive in its **habitat**. Coach students to record what they observe and what these observations mean about the animal's adaptation to its environment.

Students may need guidance on using hand lenses if they don't have much experience with them.

Allow 15-30 minutes depending on interest.

Closure: Invite each student to share their scientific drawing of the animal's structure and body parts, and to describe one thing they observed (or infer) about how the animal uses its body or part of its body to survive in its specific habitat. Support students in highlighting details they have noticed and drawing inferences about how these adaptations help the animal survive (grow, reproduce, move, etc.) in the habitat in which it was found. Invite other students to extend these ideas, ask questions, or propose other explanations.

SCIENCE CURRICULUM - NEXT GENERATION STANDARDS

5E NOTES: Look in this lesson for ways the students EXPLAIN the content:

NGSS NOTES: Look in this lesson for opportunities to practice or reach the following NGSS dimensions

Science and Engineering Practices:	Evidence you notice
#2 Developing and Using Models	

Disciplinary Core Ideas:	Evidence you notice
For any given habitat, some organisms will survive well, some will survive less well, and some will not survive at all.	

Cross-Cutting Concepts:	Evidence you notice
#6 Structure and Function. The way an object is shaped or structured determines many of its properties and functions.	

CCSS Links:	Evidence you notice
Math	
ELA	

Elaborate: Extend students’ conceptual understanding through opportunities to apply knowledge, skills, and abilities. Learners transfer what they have learned and develop a broader, deeper understanding and refine their skills and abilities.

Analyze Data to Support Habitat Design

Summary:

In this activity, students tabulate the data from their class animal collection and use the I² (Identify and Interpret) strategy to analyze their findings.

Materials needed:

- Data tabulation sheet
- Pencils

What happens:

The teacher explains that students can use the data they recorded when they collected their study animals to help them understand the types of habitats where their animals can survive. The scientific practice of data analysis is an important part of the work of scientists. The teacher models on a projector or easel, using an artificial set of data, how to transcribe data from the field sheet to the bar charts. See sample at end of lesson.

Students will need to exchange data with others. (The teacher may point out that collaboration is an important part of the way scientists work.) They will need to visit with other students who captured an animal of their study species to record the temperature, humidity, and exposure of the habitat. This activity will take about 15 minutes as students circulate to record about five individuals of the species they are studying. For example, a student working with roly polies will need to walk around to all others who collected a roly poly. They record the data point with an X on the appropriate bar for each of the three graphs.

The students have now constructed three bar graphs to show the attributes of habitats where they found their animals. The teacher facilitates the three-step I² strategy by modeling it with an artificial data set on an easel if outdoors, or projector if indoors:

1. Noticing the shape or pattern of the data (Identify)
Students label the graph with their observation, e.g. “The moist column is the highest.”
2. Inferring what that means about the real-life situation (Interpret)
Students label an inference just under the observation, e.g. “More roly polies prefer a moist environment than a dry or wet one.”
3. Writing a short paragraph caption (Communicate)
Students combine their inferences into a paragraph, such as “More roly polies were found in moist environments, cool environments, and dark environments. I would expect to find them in places that have some moisture and aren’t too hot. I would expect to find them underneath something.”

SCIENCE CURRICULUM - NEXT GENERATION STANDARDS

Closure: Students share their findings after completing the data sheet with its labels and captions. The teacher then facilitates a discussion of how this information might help them design the artificial habitat. What will they need to do or provide to make a home for their animal that is similar to the natural habitat?

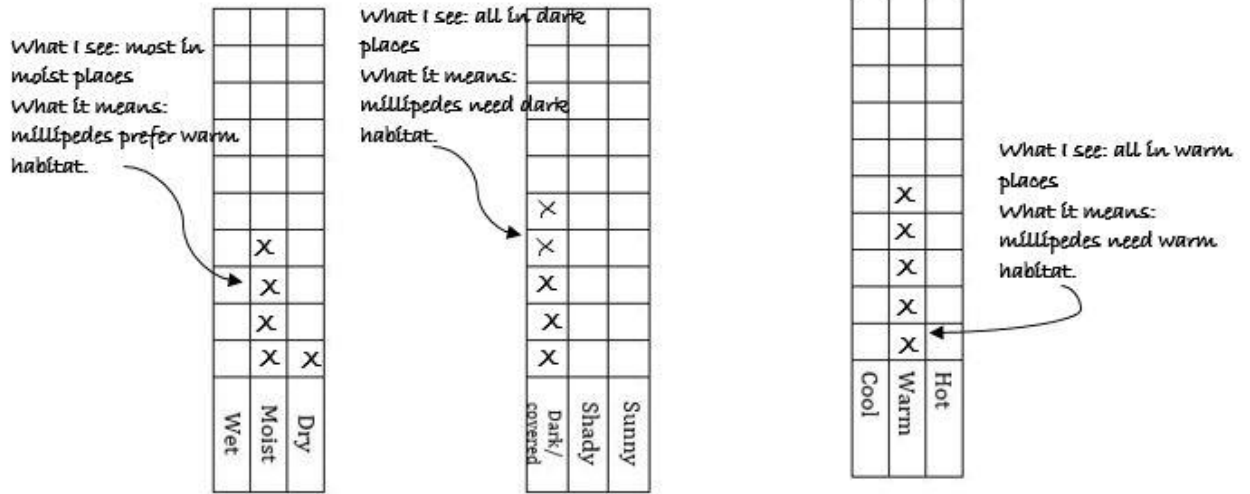
SCIENCE CURRICULUM - NEXT GENERATION STANDARDS

Sample (Fictitious) Data Set for Graphing Demonstration

Lesson 4: Graphing Data

The Identify and Interpret Strategy

- Record field data by filling in a box for each animal of your study species collected by you or another scientist.
- What do you notice? Use arrows and words to show what patterns you can identify in your 3 graphs.
- What does it mean? For each thing you noticed about your graph, write a short phrase to interpret what it means about your animal in its habitat.
- Put your ideas together into a paragraph caption explaining what these data tell you about your animal and its habitat.



Caption:
I noticed that most millipedes were found in moist places and all millipedes were found in dark and warm places. This means that millipedes survive in habitats that are warm, dark, and usually moist.

SCIENCE CURRICULUM - NEXT GENERATION STANDARDS

5E NOTES: Look in this lesson for ways the students ELABORATE the content:

NGSS NOTES: Look in this lesson for opportunities to practice or reach the following NGSS dimensions

Science and Engineering Practices:	Evidence you notice
#4 Analyzing and Interpreting Data	
#6 Engaging in Argument from Evidence	

Disciplinary Core Ideas:	Evidence you notice
For any given habitat, some organisms will survive well, some will survive less well, and some will not survive at all.	

Cross-Cutting Concepts:	Evidence you notice
#1 Patterns. Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.	

CCSS Links:	Evidence you notice
Math	
ELA	

Evaluate: Students assess their ideas, concepts and practice—based on the performance expectation set out at the beginning of the unit. The assessment also embeds evaluation of the competencies described in the performance expectations.

Create a Habitat

Materials needed:

Drawing materials
UC Cooperative Extension “pest notes” or other texts on garden animals
Judging sheets, one per student

Summary:

Students design an effective habitat for their study animal in which it could survive away from the garden. Note that this is both an assessment of the performance expectation and a start of an engineering learning opportunity. (To fully meet the engineering performance expectation, students would need to construct the habitats and evaluate their effectiveness in real time—see Extension lesson below.) The activity culminates with a “gallery walk” of the different designs, with students acting as judges evaluating the strengths and needs of other teams’ designs.

What happens:

The teacher begins by describing the challenge: today students will use all the data they have collected about their animal to design a place for their animal to live inside the classroom—an artificial habitat. Their design must be based on evidence they have collected along with text evidence from outside experts. It will be a poster with drawings and text to convince their classmates that their design is a safe and healthy place for their animal to live.

Begin by introducing the University of Arizona Center for Insect Science Education Outreach fact sheets to students (<http://insected.arizona.edu/>). These are publications with information about beneficial, harmful, and neutral garden animals. Students will use the main ideas from these texts as supporting evidence for their habitat design. The teacher projects one of the fact sheets. The teacher invites students to help find and highlight ideas about how the animals use their **adaptations** to meet their needs in their **habitat**, reminding students that they will need to help the animal meet the same needs in the habitat they design. (It’s also great to model scribbling design ideas in the margins while reading!)

The teacher explains that this is an engineering challenge. Engineers propose solutions to problems, and in this case the problem is to make a safe and healthy place for a garden animal to live inside a classroom. Engineers create solutions based on research—in this case the field observations, data analysis, and now also the text resources. The design diagram and narrative text must refer to these three data sources.

SCIENCE CURRICULUM - NEXT GENERATION STANDARDS

The teacher then explains the design requirements for the habitat and components for the design poster:

Design Requirements:

1. Meets the needs of your study species for food, water, oxygen, and protection, based on your research into this species.
2. Can be constructed out of ordinary, inexpensive or free materials (recycled/reused materials preferred).
3. Keeps the animal safely contained in a space no larger than a cube 30x30x30 cm.

Design Components (arrange on an 11 x 17 poster):

1. A clearly labeled diagram of the habitat, including a title
2. A one-paragraph description of why the habitat is the best way to meet the study animal's needs, based on the animal's adaptations.
3. A list of materials needed
4. Field sketches (from Activity 3)
5. Graphs with annotations and captions (From Activity 4)

Assessment:

Students should demonstrate the Performance Expectation in their design and narrative paragraph. The teacher will rate each design as successful if it explicitly includes ways to meet the animal's needs for shelter, water, and food in the artificial habitat, and if it is clearly based on field observations, data analysis, and text research.

Full credit: the diagram refers to the drawing and graphing results and to text resources; it meets the project criteria for meeting survival needs, using ordinary materials, and meeting the size limit.

Partial credit: the diagram does not link the animals' needs to the design, or does not meet other project criteria.

No credit: the diagram does not address the animals' needs clearly, or does not meet any of the project criteria.

Students will also demonstrate the Performance Expectation by showing their understanding that some organisms survive better in some habitats than others. As they circulate during the gallery walk, they choose five habitat designs and evaluate whether their own study species could survive in them, using the judging sheet.

Closure: The teacher facilitates a discussion of what students now know about what garden animals need in order to survive. Ask what they would do to test their designs to improve the habitats' ability to help their study animals survive. Consider carrying out the engineering extension (attached) to build skill and understanding of testing solutions to identified problems.

SCIENCE CURRICULUM - NEXT GENERATION STANDARDS

5E NOTES: Look in this lesson for ways the teacher and students EVALUATE their mastery of the content:

NGSS NOTES: Look in this lesson for opportunities to practice or reach the following NGSS dimensions

Science and Engineering Practices:	Evidence you notice
#7 Constructing Explanations and Designing Solutions	

Disciplinary Core Ideas:	Evidence you notice
For any given habitat, some organisms will survive well, some will survive less well, and some will not survive at all.	

Cross-Cutting Concepts:	Evidence you notice
#4 Systems and Systems models	

CCSS Links:	Evidence you notice
Math	
ELA	

Extension: Connect these lessons to a new Performance Expectation

Testing Habitat Design

This assessment could be carried into an Engineering Design Performance Expectation by actually constructing the habitats and observing how well the organisms survive in them over the course of days. Students could maintain an engineering journal and record observations and modifications over a period of days or even weeks. This could include tests of preferred food, lighting, temperature, humidity, etc. See [Creepy Crawlies and the Scientific Method](#) for more ideas.

If you choose to actually construct the habitats you will also need:

Various containers (recycled) with lids: clear produce boxes, inverted plastic cake boxes, jars, yogurt containers, etc.

Screen wire or other type of mesh

Tape

Glue

Cardboard

Plastic wrap

Rubber bands

Tape

Foil

Popsicle sticks

Carrots and/or potatoes

A small amount of dry dog food

Wingless fruit fly culture if you have any predators (available at pet stores)

Sponges

String

Fabric

Paper towels and their tubes

Garden soil or potting soil mix

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The performance expectation below would be appropriate for this extension:

3-5-ETS1-2 Engineering Design		
<p>Students who demonstrate understanding can:</p> <p>3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.</p>		
<p>The performance expectation above was developed using the following elements from the NRC document <i>A Framework for K- 12 Science Education</i>:</p>		
<p>Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 3–5 builds on K–2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems.</p> <ul style="list-style-type: none"> • Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design problem. 	<p>ETS1.B: Developing Possible Solutions</p> <ul style="list-style-type: none"> • Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions. • At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. 	<p>Influence of Science, Engineering, and Technology on Society and the Natural World</p> <ul style="list-style-type: none"> • Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands.
<p><i>Connections to 3-5-ETS1.B: Developing Possible Solutions Problems include:</i></p> <p>Fourth Grade: 4-ESS3-2</p>		
<p><i>Articulation of DCIs across grade-levels:</i></p> <p>K-2.ETS1.A ; K-2.ETS1.B ; K-2.ETS1.C ; MS.ETS1.B ; MS.ETS1.C</p>		
<p><i>Common Core State Standards Connections:</i></p> <p>ELA/Literacy -</p> <p>RI.5.1 Quote accurately from a text when explaining what the text says explicitly and when drawing inferences from the text. (3-5-ETS1-2)</p> <p>RI.5.1 Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently. (3-5-ETS1-2)</p> <p>RI.5.9 Integrate information from several texts on the same topic in order to write or speak about the subject knowledgeably. (3-5-ETS1-2)</p> <p>Mathematics -</p> <p>MP.2 Reason abstractly and quantitatively. (3-5-ETS1-2)</p> <p>MP.4 Model with mathematics. (3-5-ETS1-2)</p> <p>MP.5 Use appropriate tools strategically. (3-5-ETS1-2)</p> <p>3- Operations and Algebraic Thinking (3-ETS1-2)</p> <p>5.OA</p>		

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Resources for School Gardening and NGSS

Center for Insect Science Education Outreach at University of Arizona,
<http://insected.arizona.edu>
Elementary curriculum for learning with live insects in the classroom

LifeLab at University of Santa Cruz, <http://www.lifelab.org>
Curriculum, workshops, blogs, advice... and a chicken cam.

The Edible Schoolyard, edibleschoolyard.org
A network of garden educators focusing on edible education; free online videos from UC Berkeley and summer institute in Berkeley.

Monterey Bay Master Gardeners, <http://mbmg.ucanr.edu>
Free advice from trained garden volunteers.

California Environmental Education Initiative, <http://californiaeei.org/>
Standards, free workshops, and free curriculum.

Project WET, <http://www.projectwet.org/>
Water-related environmental curriculum and free teacher workshops.

National Science Teachers Association, <http://www.nsta.org/>
Members can develop and carry out self-assessment and guided professional development in content and instructional strategies; great links to NGSS information.

National Science Teachers Association NGSS resource page, <http://ngss.nsta.org/>

Next Generation Science Standards, <http://www.nextgenscience.org/>

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References

- Bybee, Rodger W. (2013). *Translating the NGSS for Classroom Instruction*. Arlington, Virginia: NSTA Press.
- California Department of Resources Recycling and Recovery (CalRecycle) (2015). *California's Environmental Principles and Concepts*. Retrieved from <http://www.californiaeei.org/>
- Center for Insect Science Education Outreach (1997). *Using Live Insects in Elementary Classrooms for Early Lessons in Life*. University of Arizona, retrieved from <http://insected.arizona.edu/>.
- Jaffe, R. & Appel, G. (2007). *The Growing Classroom: Garden-Based Science*. South Burlington, VT: National Gardening Association.
- Kneidel, S. (1993). *Creepy Crawlies and the Scientific Method*. Golden, CO: Fulcrum Publishing.
- Laws, J., Breunig, E., Lygren, E., and Lopez, C. (2012). *Opening the World through Nature Journaling*. Sacramento: California Native Plant Society.
- National Research Council (2013). *Next Generation Science Standards: For States, By States*. Washington, DC: The National Academies Press.
- Simmons, B. (2010). *Excellence in Environmental Education—Guidelines for Learning (K–12)*. Washington, DC: North American Association for Environmental Education. Retrieved from <http://eelinked.naaee.net/n/guidelines/posts/Excellence-in-Environmental-Education-Guidelines-for-Learning-K-12>

Student Materials

During the workshop you will use the same worksheets as kids would in the same activity. Mark up one set and keep the other for your classroom.

Use this sheet for any notes on the activities.

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Lesson 2: **Field Exploration**

Observers' Name: _____ Date: _____ Time: _____

For each individual animal you collect, complete one line of the data form. Once you have five animals for your study collection, stop and choose one to sketch in detail. Leave the rest in the collection box with some of their substrate, in the shade.

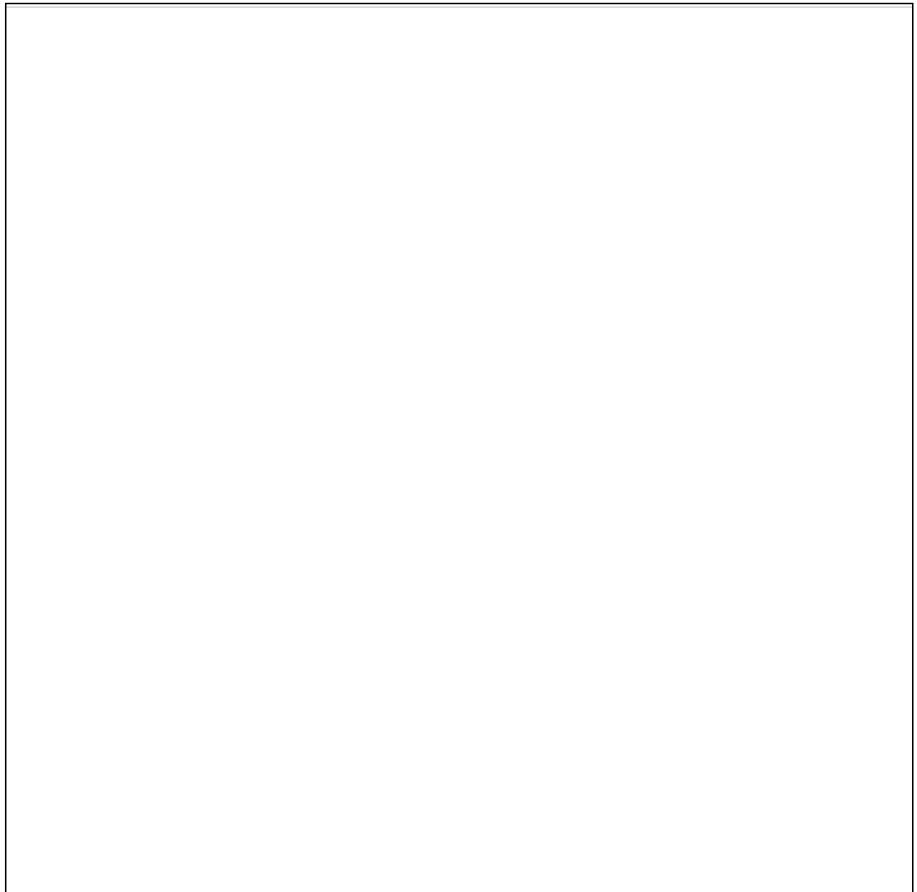
Species	Location	Substrate	Behavior (how it moves, what it eats, what it's doing, etc.)	Moisture	Temperature	Exposure
EXAMPLE worm	Compost bin	Rotting leaves	Wiggling, digging	Wet Moist Dry	Cool Warm Hot	Covered Shady Sunny
1				Wet Moist Dry	Cool Warm Hot	Covered Shady Sunny
2				Wet Moist Dry	Cool Warm Hot	Covered Shady Sunny
3				Wet Moist Dry	Cool Warm Hot	Covered Shady Sunny
4				Wet Moist Dry	Cool Warm Hot	Covered Shady Sunny
5				Wet Moist Dry	Cool Warm Hot	Covered Shady Sunny
6				Wet Moist Dry	Cool Warm Hot	Covered Shady Sunny

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Lesson 3: **Field Sketch**

A field sketch is like a brain photograph. You are the camera! Look closely at every detail of your animal.

1. Start by looking at the shape of the body. Don't worry about arms and legs and small parts yet. What shape do you see? Draw that shape bigger than real life, using nearly the whole space.
2. Add other body parts like arms, legs, claws, antennae. Pay attention to the sections or segments of the animal's body. Can you see where they connect? What shape are the eyes? What mouth parts do you see? Are there patterns or textures on the animal's surface?
3. Use arrows and labels to tell what you notice about the animal. Include your ideas about how you think the body parts help the animal survive (find and eat food and water, move, stay safe, reproduce). Draw or write measurements, behaviors, and anything else that helps you explain how the animal's body parts and behaviors help it survive in its environment.



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Lesson 5: **Habitat Design**

Now you have collected and analyzed data about your animal. You have information from observing and drawing the animal's body structures and behaviors (adaptations), and you have analyzed data about the qualities of the places the animals were found (habitat). Using this information, along with texts about the animal's life cycle, make a design for an artificial habitat—an animal home you could build—where your animal could survive in your classroom.

The Problem: Provide a home where a garden animal can survive inside a classroom.

Design Requirements:

1. Meets the needs of your study species for food, water, oxygen, and protection, based on your research into this species.
2. Can be constructed out of ordinary, inexpensive or free materials (recycled/reused materials preferred).
3. Keeps the animal safely contained in a space no larger than a cube 30x30x30 cm.

Design Components (arrange on a poster):

1. A clearly labeled diagram of the habitat
2. A one-paragraph description of why the habitat is the best way to meet the animal's needs.
3. Field sketches (from Activity 3)
4. Graphs with annotations and captions (From Activity 4)

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Peer Assessment of Designs

Visit at least five of your fellow scientists' designs. Think about whether your study animal could live in the habitat they designed.

Habitat Title	Designer	My study species, _____ could meet these needs in the habitat:				Could your study species survive in this habitat? Why or why not?
		Food	Water	Oxygen	Safety	

Write a note below to one of the designers telling what you liked and what you would like to change about their design:

Dear _____

Sincerely,

Appendix E: Comments from Expert Reviewers

Lesson 1: Imagining Habitat (ENGAGE)

Where are these [learning outcomes]? Is it the Performance Expectation?

There's a bulleted list on first page. If those are the learning outcomes you might head up the list with that label.

Is this [design problem] part of your learning outcome? Would you want to also include the NGSS box for 3-5 Engineering Design?

Does it overarch or culminate?

Lesson fully integrates discovery, observation, data acquisition, data processing, reaching conclusions, and taking action on findings.

Great closure questions!

I would add maybe discuss and draw possible animals in the garden.

Lesson 2: Field Collecting (EXPLORE)

Any [science ideas] in particular?

This session focuses on linking/recording the organism with its habitat conditions, and next focuses on structures and behaviors. Unless you ask kids to observe animals "in place" before collecting, they're not addressing the "adaptations" idea until later.

Nice breakdown [of data recording].

Could be useful to give some ideas of how to find creatures: i.e. doing a sheet shake (where you put a sheet under a branch of a bush and shake the bush until a bunch of bugs fall out), looking under logs, etc. (You mentioned the logs, but I think a section on "Ways to find creatures" could be helpful to people who are feeling unsure).

You elicit the concept of operational definition very nicely, providing students with a means of assessing temperature, moisture, and the like in the garden. I think it is of value to communicate the concept with students through discourse, perhaps some reading: "How can we agree on an observation about garden conditions such as moisture or temperature? If Angelica says that the soil under the rock is wet, but Charles says it is only moist, how can we decide which of the two students is correct? Is there a way we can help Angelica and Charles reach the same decision about the soil under the garden rock?" Example operational definition: "A time period of 72 hours or longer of above average daily and night time temperature that follows the first killing frost" ----- Indian Summer.

I appreciate the emphasis of how to walk in the garden and how to collect and treat those who live in the garden.

For the Data Recording section, I would practice with the students as to what is "wet, dry, moist,

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cool, warm" etc. I would also include a spot for writing down the time of day and repeat this activity at different parts of the day.

Lesson 3: Field Collecting (EXPLORE)

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This session focuses on linking/recording the organism with its habitat conditions, and next focuses on structures and behaviors. Unless you ask kids to observe animals “in place” before collecting, they’re not addressing the “adaptations” idea until later.

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Lesson 4: Analyze Data (ELABORATE)

Glad you define this [I² strategy] below. Is this hardwired in CA teachers?

"...to help them understand the types of habitats their animals prefer. " Aha – here it is. Do you mean “prefer” or “where their animals live”/”where their animals can be found”?

Practice 4: Analyzing and Interpreting Data

“Represent data in tables and/or various graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships.”

[Closure] Nice.

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Maybe instead of "caption" you could write the prompt (#4) from above: "Put your ideas together ... "

Great flow!

Would you have one Data Set For Graphing sheet per animal to identify the conditions of where most are found? It might be easier to argue why it should/should not live in a particular area if they have a ton of data on each animal.

Lesson 5: Create a Habitat (EVALUATE)

Why not quote it [performance expectation] here? Is the Performance Expectation shared with the students?

Since this particular activity doesn't employ the same practice as the Performance Expectation ("Construct an argument with evidence") you might claim evidence of mastery of the Disciplinary Core Idea instead (employing a different practice). Also haven't addressed Cause and Effect Cross Cutting Concept in any direct way.

[University of Arizona Center for Insect Science Education and Outreach] Include a link here for easy access? The teacher projects one; would she print out others for the organisms the children collected?

"in this case the field observations, data analysis, and now also the text resources. "--Nice to spell this out for students (and teacher).

This is the first mention of a design poster. Maybe include earlier in summary to teacher and students so the "product" of the day can be anticipated. Is it on the Materials list or is it just 8.5x11 piece of paper?

If ["Students should demonstrate the Performance Expectation in their design and narrative paragraph."] is true, would need to do:

3-LS4-3. Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all.

Is this [expectation for full credit] in addition to the project criteria shared with the children and referred to next?

Graphing results gave typical environment/habitat, and drawings gave structures and how they are used. Needs (air food water...) came from research.

Maybe just omit this first half of the sentence, since the "meets the project criteria..." takes up success of the design to meet survival needs.

["some organisms survive better in some habitats than others"]; Good match for the Disciplinary Core Idea quoted at top (LS4.C).

I would imagine students could use a graphic organizer for when they're reading the UofA Fact Sheets. Maybe a simple table to record habitat characteristics and physical adaptations that help them survive in that type of habitat or something ...

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Each of the other lessons laid the groundwork for this compliant end product. Tying up the missing components as you work toward the finale is in the fine tuning and making some time consuming trade offs. As I said earlier, this will be the real challenge.

Good luck to you!

The other suggestion related to integration of Common Core State Standards literacy skills with your NGSS standards. Students could read about garden animals they might encounter in an appropriate grade level informational source (e.g. Ranger Rick) and/or observe videos of the various organisms following their recording of data. If done after the fact, it would not contaminate their investigation, but would serve to validate their efforts and augment their understanding of the animals they are investigating. This might be done as they design their habitats. They could be asked to describe how their learning from reading affected their final habitat designs.

The construction of the habitat in keeping with findings is a strength of the whole unit. The one thing I am not too clear about is the part where the Performance Expectation states the "system in which the parts depend on each other". I think this element is missing from the elaborate/evaluate portion. Perhaps students can discuss the interactions between the animal and habitat or maybe defend why some animals will be more successful in a particular part of the garden as opposed to another part of the garden.

Lesson 6: Testing Habitat Design (EXTENSION)

Is this whole lesson sequence an assessment? To perform the Performance Expectation ? If so I didn't notice it labeled so earlier.

Or is this Extension another "Evaluate" for 5E? (I'm guessing not, since it's after a different NGSS set.)

A more direct "hit" for the Performance Expectation would compare different kinds of structures that children built to house the same kind of organism, to see if organisms thrive in each. (Since the "problem" is defined as making an appropriate habitat.)

Messing with variables like this could be aimed toward a different ETS Performance Expectation :

3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

Content and Structure of the Workshop

You might add some pointers (with acronyms and long-names) to the components on this page you expect them to find on the next page.

Your summary on page 1 says there will be an introduction to the structure of the NGSS, but all I see is this page, with no tips about which is Performance Expectation , Disciplinary Core Idea, Scientific and Engineering Practice, Cross Cutting Concept, or Common Core State Standards. Personally, on the next page I didn't know what EEI was -- but found "environmental education

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initiative” by searching your doc and finding a reference in the bibliography.

Did you intentionally omit the Performance Expectation ? Fine if the lesson plan doesn't promote that performance – but seems like it could if it is aiming for only that practice, Disciplinary Core Idea, and Cross Cutting Concept.

I wish there was room to quote the Disciplinary Core Ideas, Scientific and Engineering Practices, and Cross Cutting Concepts on the same table. (Common Core State Standards is too long). I'm assuming you're expecting them to identify from the previous NGSS table. Or do you expect teachers to have a wide familiarity (or documents) to match other components than the ones you quoted on the table?

Is this [table] compact enough to be included in your document, in a table under the NGSS box, so they can refer to what is wanted? Or do teachers in California have this hardwired?

Not the stereotypical use of a school garden; offers depth and means of first creating and then satisfying students' curiosity

Clear progression from introductory lesson through to the end

love the verbs: its great

I have read your lesson plans, noted your use of field work, student application of Roger Bybee's investigation methodology, data recording instruments and student instructions. I believe your curriculum unit is a model of effective instruction based on the Next Generation Science Standards. I am quite impressed with the way you have integrated Bybee's work with a model activity to help teachers understand the NGSS.

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Appendix F: Implementation Timeline

NGSS IMPLEMENTATION – STATEWIDE AND DISTRICT ACTIVITIES			
Timeframe	Statewide Activities	ASJUSD Activities	ASJUSD Needs and Sources
2013 – 2016 Overlaps with Transition Phase	NGSS <u>Awareness Phase</u> - represents an introduction to the CA NGSS, the initial planning of systems implementation, and establishment of collaborations.	<u>Awareness Phase</u> - setting NGSS priorities, identifying lead teachers at all grade bands, identifying partners	
Sept. 2014 – May, 2015	Framework committee works on revision of the Science Curriculum Framework. Meeting Dates: September 9-10; October 9-10; November 5-6; January 22-23 and March 26-27; and May 20-21.	Anzar High School science teachers attend Rollout Symposium #1 to become familiar with NGSS; begin collaborating on pilot units of study based on NGSS	Funded by AHS?
		Environmental Education Initiative at Aromas School familiarizes teachers with one available NGSS-supporting curriculum. Project WET curriculum is also available through a workshop that can be provided by Laura Arnow	Free workshop provided by CalRecycle and EEI Ambassadors
	5th, 8th, and 10th graders take existing CST/CMA/CAPA science test. - Test scores will be reported to parents but will not be a part of the 2014/2015 API	5th, 8th, and 10th graders take existing CST/CMA/CAPA science test. - Test scores will be reported to parents but will not be a part of the 2014/2015 API	N/A

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NGSS IMPLEMENTATION – STATEWIDE AND DISTRICT ACTIVITIES			
Timeframe	Statewide Activities	ASJUSD Activities	ASJUSD Needs and Sources
June-August 2015	PROPOSED: IQC Science Subject Matter Committee (SMC) reviews draft Science Curriculum Framework.	ASJUSD Board approves NGSS implementation plan; sets science education as a priority; clarifies support for school gardens and habitat sites.	N/A
		If funded by Honda Foundation, hire a garden coordinator. If not funded, begin seeking financial support for a coordinator in other ways.	Consider seeking a classroom teacher willing to be released by a once-a-week sub; requesting similar funding from other sources; using USDA nutrition funds to use the garden for nutrition/science teacher
		Begin garden instruction in K-8 schools	
		Anzar High School teachers plan NGSS based course for Earth Science for 2015-16	N/A (collaboration time)
		ASJUSD identifies lead science team at K-2, 3-5, and 6-8 grade bands; plan to send team to Rollout #2 in Hayward	N/A
September 2015	PROPOSED: Draft Science Curriculum Framework approved by IQC for public review.	Weds. PD introduces K8 staff to NGSS dimensions	N/A
		Project WET/NGSS Intro Professional Development opportunity (six hours), emphasizing ways to integrate garden with science	No cost to district for the workshop; teacher materials are provided at no cost and teachers may receive Continuing Education Units for a fee. District will need to provide some incentive in the form of classroom grants, snacks, and materials. Estimated cost if 15 teachers attend: \$400; consider asking local water districts and/or growers for support for this workshop.

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NGSS IMPLEMENTATION – STATEWIDE AND DISTRICT ACTIVITIES			
Timeframe	Statewide Activities	ASJUSD Activities	ASJUSD Needs and Sources
October – November, 2015	CSTA Annual California Science Education Conference – Sacramento, CA October 2 – 4, 2015	Send representatives of ASJUSD science team to CSTA	Seek funding for registration, travel, housing, and subs for at least one teacher from each grade band (K-2, 3-5, 6-8, 9-12) representing all threeschools.
		Harvest Festivals at both K-8 schools, ongoing instruction in the gardens.	Apply for garden grants from Western Growers, California Native Gardens, and others. Request a Master Gardener to assist at each site.
		Teachers and students planning and planting habitat gardens, if funded; site preparation and acquiring plants	Request support from local native plant nurseries and Graniterock. Send garden coordinator to training at LifeLab for Creating and Sustaining Your School Garden and Garden Enhanced Nutrition Education; apply for summer Edible Schoolyard Academy
	NGSS Rollout Symposium #2	Lead teacher team K-12 attends Rollout #2 in San Jose or Hayward	Travel plus \$250 registration for the 2-day symposium; send a team of threeteachers and an administrator.
	PROPOSED: First 60-day public review period of Science Curriculum Framework.	Science team reviews Framework and presents summary to staff at sites Lead teachers work with their grade level to begin collaborating on pilot units (one performance expectation unit per grade band)	Release time for lead teachers to prepare staff presentation
December 2015 - January 2016	Current deadline for State Board of Education to approve curriculum Science Curriculum Framework per SB 300 (Hancock, 2013)	Pilot locally developed units in classrooms K-12; administrators and colleagues observe informally; teams self-evaluate at end of unit	Wednesday PD days
		Ongoing garden education (indoors if necessary) such as propagation, nutrition activities, and further planting in habitat gardens.	Apply for California Native Gardens Foundation grant, Fiskars, Whole Kids, and others.

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NGSS IMPLEMENTATION – STATEWIDE AND DISTRICT ACTIVITIES			
Timeframe	Statewide Activities	ASJUSD Activities	ASJUSD Needs and Sources
February 2016	IQC Science SMC reviews results of public review of Science Curriculum Framework and makes edit recommendations.		Plan to apply for Ocean Guardians grant in early May
2015-2018 Overlaps with Awareness Phase and Implementation Phase	NGSS <u>Transition Phase</u> – build foundational resources, implementing needs assessments, establishing new professional learning opportunities, and expand collaborations between all stakeholders.	ASJUSD <u>Transition Phase</u> – lead teachers pilot units, continued professional development for and by lead teachers, new needs assessment, professional development for all teachers by lead team and outside organizations	
April - December 2015	NGSS Statewide Rollout #2 - various dates and locations.	Lead team attends Rollout #2	Travel plus \$250 registration for the 2-day symposium; send a team of threeteachers and an administrator.
January - February 2016		Grantwriting for the gardens; move toward science with nutrition in the vegetable/fruit gardens. Seek funding for a garden kitchen.	Apply for Edible Schoolyard Academy with a teacher from each school
		Planting perennials, natives, fruit trees	Seek donations from local growers
March-April 2016	Deadline for the SSPI to submit plan for science assessments not required by the Federal government.	Ongoing NGSS education; lead teachers facilitate further planning of grade level units and revision and sharing of first round of units. Seek additional support in the form of free NGSS-related resources and support teachers evaluating NGSS-appropriateness of available resources.	Schedule Wednesday PD for science.
		Spring planting; maintenance; plan Spring Festival; support Ocean Guardians grantees in outreach.	Seek second year funding from Ocean Guardians for further habitat work or to switch topics, depending on staff and student interest.

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NGSS IMPLEMENTATION – STATEWIDE AND DISTRICT ACTIVITIES			
Timeframe	Statewide Activities	ASJUSD Activities	ASJUSD Needs and Sources
May 2016	PROPOSED: IQC analyzes results of public review, revises draft, and approves second draft of Science Curriculum Framework for public review.	Lead team shares second draft of Framework with staff; staff proposes next round of units to develop for 2016-2017	Release time for lead team to plan PD day
	5th, 8th, and 10th graders take existing CST/CMA/CAPA science test.	5th, 8th, and 10th graders take existing CST/CMA/CAPA science test.	
		Spring Festival/Open House celebrates the garden project; harvest and nutrition classes in the garden	Garden coordinator seek support for Spring Festival; assist with inviting community members for Outreach element of Ocean Guardians
June – July, 2016*	PROPOSED: Second 60-day public review period of Science Curriculum Framework.	Garden maintenance; volunteers harvest, automated irrigation and mulch	Lead team meets to to plan NGSS work for 2016-17
August 2016		ASJUSD science team reviews and presents Science Curriculum Framework to Board/curriculum committee and to staff	Wednesday PD and Board meeting
September 2016*	PROPOSED: SBE to take action on the proposed Science Curriculum Framework.	Staff begin piloting new units and reteaching original units	
		Garden instruction begins	District must secure funding for another year of garden coordinator
2016 and beyond	NGSS <u>Implementation Phase</u> – expand professional learning support, fully align curriculum, instruction, and assessments, and effectively integrate these across the field.	ASJUSD <u>Implementation Phase</u>	
2016-2017	Anticipated Pilot Testing Year for NGSS Assessment.	Science lead team communicates testing protocols with administrators and teachers	Wednesday PD day and possible release days for lead team to be trained in testing protocol

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NGSS IMPLEMENTATION – STATEWIDE AND DISTRICT ACTIVITIES			
Timeframe	Statewide Activities	ASJUSD Activities	ASJUSD Needs and Sources
September - December 2016		Science lead team and/or cooperating organizations coach teachers to develop, implement, and assess units of science study	Wednesday PD day(s)
May 2017	5th, 8th, and 10th graders take existing CST/CMA/CAPA science test.	5th, 8th, and 10th graders take existing CST/CMA/CAPA science test.	
2017 – 2018	Anticipated Field Testing Year for NGSS Assessment.	Anticipated Field Testing Year for NGSS Assessment.	
November 2018*	PROPOSED: Instructional materials adoption by SBE.	Science lead team evaluates and proposes science instructional materials candidates for adoption	District allocates and expends funds for new curriculum adoption.
2018 - 2019	Anticipated Administration of Operational NGSS Science Assessments	Anticipated Administration of Operational NGSS Science Assessments	