Introduction to the NGSS Playbook

In 2012, elementary students in Oregon spent just 1.9 hours per week learning science\(^1\). That was the lowest amount of instructional time across the entire United States.

The NGSS Playbook is intended to provide instructional leaders the background, action steps, and resources needed to guide and support the implementation of the Next Generation Science Standards (NGSS) within your district or school, and among teams of teachers. Navigating the NGSS and the instructional shifts required to implement them successfully is not easy work! This tool will give you implementation ideas, examples of best practice from the field, look-fors of quality science instruction, suggestions for integrating science instruction with the Common Core State Standards (English Language Arts and Math), and strategies for attending to equitable instructional and assessment practices.

THE GOAL: NGSS FOR ALL STUDENTS!

Across the country, schools are focused on preparing students for college, career, and life in the 21st century. The NGSS are three-dimensional, addressing the practices of scientists and engineers, the core ideas of the various domains of science, and the crosscutting concepts that connect all of these domains. In addition to phenomena in earth and space science, life science, and physical science, the NGSS also include Engineering as a separate domain in order to prepare students to design solutions to global problems.

EARLY SCIENCE INSTRUCTION IS CRITICAL FOR READING AND MATH SUCCESS

It is a widespread myth that science is not a necessary component of a child's elementary educational experience, as there are numerous well-documented benefits of learning science in the early years. According to the Education Commission of the States (2014), there are several benefits from teaching science to even the youngest children. Instead of detracting from literacy development, teaching science in the primary grades supports domain-specific vocabulary acquisition and comprehension in multiple contexts -- both key goals of reading with understanding by third grade. Further, school readiness in science and social science both more accurately predict student achievement in fifth grade than reading readiness.


BARRIERS TO TEACHING SCIENCE IN ELEMENTARY GRADES

“Where is the time to teach science?” “What resources do we have to teach these new standards?” “How do we build the capacity and confidence of our staff without ‘the plate’ being too full?” “Should science be a priority when students can’t yet read?” These are real questions and real barriers. That is why this NGSS Playbook was designed -- not only to show the necessity of quality science instruction, but to help you (an instructional leader!) overcome these barriers with guidance and support.


Access the NGSS Playbook online: [http://bit.do/ngssplaybook](http://bit.do/ngssplaybook)
As you read the *NGSS Playbook*, use this planner to create an NGSS action plan for your district, school, or teaching team. Be sure to check out the linked resources for effective practices and more information.

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>GUIDING PRINCIPLES AND QUESTIONS</th>
<th>ACTION STEPS (Personal and Team Professional Learning, Policy, Communication, etc.)</th>
</tr>
</thead>
</table>
| **Understanding the Framework of NGSS** | ❑ Are teachers familiar with the three dimensions of NGSS?  
❑ Performance expectations indicate what students should be able to do after a unit of instruction.  
❑ NGSS are connected to Common Core standards.  
❑ How does providing time for students to be curious and wonder fit with our instructional values?  
❑ How much time do we spend teaching science? | |
| **Instructional Strategies for Equity and Engagement** | ❑ What opportunities do we create for sense-making student discourse?  
❑ To what degree do we maintain high expectations for ALL students?  
❑ What grouping strategies do we use?  
❑ When possible, make connections to students’ home, language, and culture.  
❑ Do classroom topics and tasks connect to students’ lives? | |
| **Science Integration with Literacy and Mathematics** | ❑ Are students engaged daily in the practices of NGSS and Common Core?  
❑ How well do students argue from evidence across content areas?  
❑ Do teachers collaborate across content areas to design integrated STEM experiences? | |
| **Designing High-Quality Assessments** | ❑ What feedback is provided to students?  
❑ To what degree do teachers use performance tasks as assessments?  
❑ How do we measure the quality of our assessments? | |

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**CREDITS AND FURTHER INFORMATION**

The *NGSS Playbook* was written collaboratively by the Oregon Science Leaders and sponsored by the Oregon Science Teachers Association ([http://www.oregonscience.org/](http://www.oregonscience.org/)). It is licensed under a Creative Commons Attribution-NonCommercial 4.0 International License.

*Please contact us at* [oregon-science-leaders@googlegroups.com](mailto:oregon-science-leaders@googlegroups.com) *with feedback.*

→ *Keep a pulse on STEM vital signs:* [http://www.changetheequation.org/](http://www.changetheequation.org/)

Access the NGSS Playbook online: [http://bit.do/ngssplaybook](http://bit.do/ngssplaybook)
Creating an instructional framework at the school or district level requires understanding the shifts required in NGSS.

The National Research Council created the *Framework for K-12 Science Education* in 2011 that wove educational research into the nature of science. The NGSS were based upon this document. From the *Framework*, a group of 26 Lead States authored the standards as well as their appendices. Oregon was one of the Lead States, and Dr. Cary Sneider of PSU was the lead author for the engineering standards. Achieve, an educational non-profit, facilitated their development in 2013.


ARE NGSS “COMMON CORE FOR SCIENCE”?

No. Common Core State Standards were funded and written through collaborative efforts of the National Governors’ Association and the Council of Chief State School Officers. The writing of NGSS was funded by states. Common Core ELA and Math standards are integrated into NGSS. Common Core does, however, contain literacy standards for History/Social Studies, Science, and Technical Subjects. As of April 2016, 17 states and D.C. have adopted NGSS. Oregon adopted NGSS as the 2014 Oregon Science Standards.


WHAT’S DIFFERENT ABOUT NGSS?

1. **NGSS are THREE-DIMENSIONAL.**
   NGSS combine Science and Engineering Practices with Core Ideas and Crosscutting Concepts. Instruction and assessment must reflect this three-dimensional nature.

2. **NGSS are written as PERFORMANCE EXPECTATIONS.**
   These state what students should be able to do at the end of a unit of instruction and are written as assessable statements. NGSS are not curriculum.

3. **NGSS build COHERENTLY from kindergarten through high school.**
   Key concepts build logically and developmentally, integrated with Common Core.

4. **NGSS are designed to help students understand PHENOMENA in the natural world and solve societal PROBLEMS.**
   The main aim of NGSS is to help students develop scientific literacy as they encounter phenomena and problems in the world around them. In addition to core ideas in science, NGSS focuses on core ideas in engineering, the nature of science, and the connection among science, technology, society, and the environment.

5. **NGSS are connected to Common Core State Standards in Math and English Language Arts.**
   Connection boxes outline this integration.
   → See the relationships among practices in this Venn Diagram: [http://bit.do/ngss-ccss](http://bit.do/ngss-ccss)

6. **NGSS allow students to be CURIOUS and WONDER.**
   Specific performance expectations and fewer standards at each grade level allow for deeper study and investigation of scientific phenomena and global challenges.

Access the NGSS Playbook online: [http://bit.do/ngssplaybook](http://bit.do/ngssplaybook)
HOW DO I MAKE SENSE OF THE NGSS?

Performance Expectations are at the top, coded by grade level and domain.
PS = Physical Science
LS = Life Science
ESS = Earth & Space Sci.

Foundation Boxes break down each practice, core idea, and crosscutting concept.

Connection Boxes show the integration of Common Core State Standards.

WHAT ARE “PERFORMANCE EXPECTATIONS”?

Performance Expectations (PEs) are what we mean by “standards.” They are designed to be readily assessable after a unit of instruction. Each Performance Expectation combines a practice with a core idea and a crosscutting concept. Here’s an example of the first PE from the image above:

K-PS2-1. Plan and conduct an investigation (practice) to compare the effects (crosscutting concept) of different strengths or different directions of pushes and pulls (core idea) on the motion of an object.

TIPS FOR ADMINISTRATORS TO SUPPORT THE IMPLEMENTATION OF NGSS

● Ensure that ALL staff, not just your science teachers, understand the connections among NGSS and Common Core Math and ELA. One key shift is to prioritize the practices above content.

● Professional development is not an event, it is a process.

● Provide coherence and ample time, not divergent workshops.

● Teachers often need to be learners before they can be effective teachers.

● Build a library of resources to include in regular communication to teachers and families.

→ The NGSS@NSTA Portal is a comprehensive resource: http://ngss.nsta.org/


● Implementing NGSS provides a natural context for interdisciplinary teachers to collaborate.

● Be visible and participate in the process. Have fun!

● Utilize social media to carry your involvement beyond the walls of the school.

Access the NGSS Playbook online: http://bit.do/ngssplaybook
NGSS Playbook: Instructional Strategies for Equity and Engagement

*Making the knowledge and skills of NGSS accessible to historically underserved students is a key priority of any implementation.*

"Equity in science education requires that all students are provided with equitable opportunities to learn science and become engaged in science and engineering practices; with access to quality space, equipment, and teachers to support and motivate that learning and engagement; and adequate time spent on science. In addition, the issue of connecting to students' interests and experiences is particularly important for broadening participation in science." — NRC Framework, p. 28


**GUIDING BELIEFS FOR AN EQUITABLE SCIENCE LEARNING ENVIRONMENT**

Each student can learn complex science. Unfortunately, each student does not have equal opportunity to engage in complex science. These opportunities will increase when teachers intentionally implement equitable instructional practices, such as those in the table below. It is important to plan instruction to connect with students' lives and experiences. In addition, it is essential to hold high expectations for all students while providing specific supports to help students meet the rigor of the NGSS. These equitable opportunities to engage in complex science will lead to more diverse perspectives and solutions and a more scientifically literate community.

*Equitable instruction starts with knowing the students in your classroom.*

To create an equitable environment for learning science, teachers must provide social learning opportunities for solving problems in local contexts.

Students who historically have not recognized science as relevant to their lives can also be engaged by promoting innovation and creativity through engineering. In addition, recognizing contributions of historically underrepresented cultures helps students see themselves as scientists.

**EQUITABLE LESSONS AND UNITS**

In order to design equitable lessons and units, teachers should use the Equal Access to Language and Science (EquALS) Criteria based on the following questions.

1. How apparent are each of the three dimensions in the teacher's approach and students' learning?
2. Is science being taught in a relevant, authentic, and meaningful context that builds on home, community, and cultural resources, and engages students to experience phenomena?
3. To what extent does the teaching promote meaningful discourse around sense-making and problem solving, and support all students in acquiring the language of science?
4. Does the teaching pay attention to students’ current understanding and ideas, use a variety of formative assessment to support student learning, deliver opportunities for differentiation of learning, provide scaffolding of challenging tasks and/or extend learning when appropriate.

Access the NGSS Playbook online: [http://bit.do/ngssplaybook](http://bit.do/ngssplaybook)
## INSTRUCTIONAL SHIFTS FOR EQUITABLE SCIENCE LEARNING

<table>
<thead>
<tr>
<th>FROM LESS EQUITABLE SCIENCE TEACHING</th>
<th>TO MORE EQUITABLE SCIENCE LEARNING</th>
</tr>
</thead>
<tbody>
<tr>
<td>frontloading vocabulary and content followed by a confirmation lab</td>
<td>facilitating common concrete experiences with connected language and sense-making</td>
</tr>
<tr>
<td>having low expectations for some students</td>
<td>having high expectations for each student</td>
</tr>
<tr>
<td>assuming students are going to make connections and see the overarching concept</td>
<td>make explicit connections among big ideas via crosscutting concepts</td>
</tr>
<tr>
<td>assessing only written products</td>
<td>using multiple representations to demonstrate learning</td>
</tr>
<tr>
<td>learning through mostly reading, writing, and watching</td>
<td>learning through multimodal experiences: doing, moving, reading, listening, speaking, watching, writing, creating</td>
</tr>
<tr>
<td>ignoring student identity by treating everyone the same</td>
<td>affirming student identity by recognizing and celebrating racial, ethnic, gender, sexuality, and language differences</td>
</tr>
<tr>
<td>assuming science is objective and unaffected by culture</td>
<td>making home, language, and cultural connections</td>
</tr>
<tr>
<td>giving most instruction orally only</td>
<td>using a variety of visual aids and props that support student access to instructions</td>
</tr>
<tr>
<td>grouping students by perceived ability</td>
<td>grouping students heterogeneously or by interest</td>
</tr>
<tr>
<td>relying excessively on independent work or perfunctory tasks</td>
<td>providing opportunities for collaboration to support discourse and sense making</td>
</tr>
<tr>
<td>providing isolated language instruction</td>
<td>supporting the development of academic language in context</td>
</tr>
<tr>
<td>presenting images of scientists from the dominant culture only</td>
<td>presenting images that reflect the racial, ethnic, cultural, and gender identities of students</td>
</tr>
<tr>
<td>learning about topics disconnected from students</td>
<td>learning about topics that connect to real life experiences of students’</td>
</tr>
<tr>
<td>assuming students don’t know much about a topic or are lacking skills</td>
<td>identifying current knowledge, experiences, and funds of knowledge prior to instruction</td>
</tr>
<tr>
<td>talking and thinking mostly by teacher</td>
<td>facilitating discourse strategies and academically productive talk and discussions</td>
</tr>
</tbody>
</table>

Access the NGSS Playbook online: [http://bit.do/ngssplaybook](http://bit.do/ngssplaybook)
NGSS Playbook: Science is a Pathway to Increasing Literacy and Mathematics Achievement

Integrating subjects will increase student achievement in all subjects.

“Tapping Into Synergies: There are significant overlaps to leverage between the new vision for K-12 science education and the approach taken with the Common Core State Standards (CCSS) in Math and ELA. Importantly, NGSS and CCSS practices overlap heavily... This allows for an unprecedented degree of cross-subject teacher learning and sharing” — STEM Teaching Tool #21

→ Read More  http://stemteachingtools.org/brief/21

The Venn Diagram above shows the relationships and convergences among the Science and Engineering Practices of the NGSS, the Common Core Standards of Mathematical Practice, and the Common Core English Language Arts Reading and Writing Anchor Standards. When the English Language Proficiency Standards are included in this organization, several themes emerge, listed in the table below.

<table>
<thead>
<tr>
<th>SHARED INSTRUCTIONAL PRACTICES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Determine Meaning</td>
</tr>
<tr>
<td>2. Interpret Meaning</td>
</tr>
<tr>
<td>3. Exchange Information</td>
</tr>
<tr>
<td>4. Respond to Complex Texts</td>
</tr>
</tbody>
</table>

→ Read more:  http://bit.do/ngss-ccss

→ Read more about leadership in the practices: http://www.sciencepracticesleadership.com/

Access the NGSS Playbook online:  http://bit.do/ngss playbook
INTEGRATED STEM UNITS PROVIDE OPPORTUNITIES TO APPLY CORE INSTRUCTION

“Advocates of more connected approaches argue that teaching STEM subjects in a more integrated way, especially in the context of real-world issues, can make these fields more relevant to students and ultimately increase their motivation and achievement.” — National Academy of Engineering

→ Read more about integrated STEM instruction: http://bit.do/k12-stem-integration

→ See the STEM attributes: http://bit.do/stem-attributes

The focus of STEM instruction is applying the knowledge and skills of the various STEM disciplines to understand and attempt to solve real-world problems. These opportunities to apply core instruction is at the heart of 21st century learning -- full of critical thinking, collaboration, creativity, and communication. One way to visualize the power of STEM is as a rope of twisted strands, each of which represents a set of core content knowledge and skills. Students must have this core instruction but must also have the opportunity to apply this core knowledge in a real-world context, as a rope would be made for doing work.

Applying mathematics during engineering design challenges can help children develop critical thinking, problem solving, and communication skills.”

— Teaching Children Mathematics

→ Read more on how STEM gives meaning to math: http://bit.do/math-in-stem

ENGAGING IN ARGUMENT FROM EVIDENCE

At the center of the Venn diagram above is the practice of engaging in argument from evidence. Common to science, engineering, math, and English language arts, this practice should be a target for student learning in any classroom experience. The nature of science and engineering is rooted in the process of gathering evidence and communicating reasoning. This practice is underscored as a Common Core anchor standard for writing.

“The study of science and engineering should produce a sense of the process of argument necessary for advancing and defending a new idea or an explanation of a phenomenon and the norms for conducting such arguments. In that spirit, students should argue for the explanations they construct, defend their interpretations of the associated data, and advocate for the designs they propose.”

— National Research Council Framework, p. 73

→ Read the Framework: http://bit.do/ngssframework

→ Read more about the NGSS Practices: http://ngss.nsta.org/Practices.aspx?id=7

→ Access professional development on argument writing: http://bit.do/ngss-argument

Access the NGSS Playbook online: http://bit.do/ngssplaybook
Assessment must measure and reflect our instructional priorities – rigor and relevance in the 21st century.

“I am calling on our nation's governors and state education chiefs to develop standards and assessments that don't simply measure whether students can fill in a bubble on a test, but whether they possess 21st-century skills like problem-solving and critical thinking, entrepreneurship and creativity.”
— President Barack Obama, March 2009

ASSESSING THREE-DIMENSIONAL LEARNING

Classroom assessments are an integral part of instruction and learning, and should include both formative and summative tasks. Formative tasks are specifically designed to measure student progress toward the intended unit outcomes at a given point in time. They are primarily used to guide instructional decision-making and lesson planning. Summative tasks are specifically designed to measure student achievement of the intended unit or course outcomes. The three-dimensional nature of NGSS require three-dimensional science assessments, but these tasks are challenging to design, implement, and properly interpret. Teachers will need extensive professional development to successfully incorporate this type of assessment into their practice.

→ Read more about developing assessments for NGSS: http://bit.do/ngss-assessments

ASSESSMENT PYRAMID

Access the NGSS Playbook online: http://bit.do/ngssplaybook
PERFORMANCE ASSESSMENTS

Many Smarter Balanced Performance Tasks use science as the context. Engaging students in science phenomena will build and reinforce background knowledge that will support students as they encounter Performance Tasks designed to assess Mathematics and English Language Arts.

The Common Core English Language Arts standards “focus on evidence-based writing along with the ability to inform and persuade [which] is a significant shift from current practice. . . . Informational reading includes content-rich nonfiction in history/social studies, sciences, technical studies, and the arts. . . . Reading, writing, speaking, and listening should span the school day from K-12 as integral parts of every subject.”
— Common Core State Standards

Integrated units of instruction are a powerful way to prepare students for the rigor of college and career infused in Common Core.

SHIFTS IN ASSESSMENT AND INSTRUCTION

<table>
<thead>
<tr>
<th>Current Assessment &amp; Instruction</th>
<th>New Assessment &amp; Instruction</th>
</tr>
</thead>
<tbody>
<tr>
<td>OAKS</td>
<td>NGSS-aligned assessment (anticipated 2017-18)</td>
</tr>
<tr>
<td>One summative assessment at each grade band</td>
<td>Ongoing standards-based summative assessments</td>
</tr>
<tr>
<td>(grades 5, 8, and 11)</td>
<td>with multiple attempts each year at all grade levels</td>
</tr>
<tr>
<td>Scientific Inquiry Work Sample, completed once per year in grades</td>
<td>Meaningful formative assessments at many points</td>
</tr>
<tr>
<td>3-8 and once in high school</td>
<td>during the year with student-centered feedback</td>
</tr>
<tr>
<td>No recommendation for instructional minutes in science</td>
<td>Districts/schools establish and follow recommendations for</td>
</tr>
<tr>
<td>Emphasis on annual summative assessment with little to no feedback</td>
<td>instructional minutes for science in PK-5</td>
</tr>
<tr>
<td>for students and teachers</td>
<td>Emphasis on ongoing formative classroom assessment with feedback</td>
</tr>
<tr>
<td>Little consistent science instruction in PK-5 leads to</td>
<td>provided to students and teachers</td>
</tr>
<tr>
<td>lack of instructional alignment PK-12</td>
<td>Daily science learning opportunities in PK-5 leads to</td>
</tr>
<tr>
<td></td>
<td>instructional alignment PK-12</td>
</tr>
</tbody>
</table>

HIGH-QUALITY NGSS ASSESSMENTS MUST . . .

- Assess higher-order cognitive skills and habits of mind
- Assess all three dimensions of NGSS (practices, core ideas, and crosscutting concepts)
- Correlate to NGSS performance expectations
- Use items that are culturally responsive and educationally valuable
- Be valid, fair, equitable, and reliable

→ Based upon Darling-Hammond, et al., 2013

Access the NGSS Playbook online: [http://bit.do/ngssplaybook](http://bit.do/ngssplaybook)