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.

→ *Read more:* http://bit.do/early-science

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.

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[1] Blank, R. K. (2012). *What is the impact of decline in science instructional time in elementary school?* [White Paper]. Retrieved from http://www.csss-science.org/downloads/NAEPElemScienceData.pdf.

CREATE AN NGSS ACTION PLAN

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.

CATEGORY	GUIDING PRINCIPLES AND QUESTIONS	ACTION STEPS (Personal and Team Professional Learning, Policy, Communication, etc.)
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?	

CREDITS AND FURTHER INFORMATION

Please contact us at oregon-science-leaders@googlegroups.com with feedback.

→ *Read more about implementing NGSS:* http://bit.do/implement-ngss

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

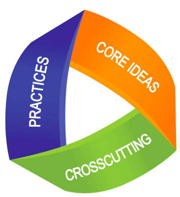
NGSS Playbook: Foundations of Instructional Framework

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.

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

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.

→ *Read the Standards:* http://ngss.nsta.org/ http://nextgenscience.org/

WHAT'S DIFFERENT ABOUT NGSS?

1. **NGSS are THREE-DIMENSIONAL.**
   NGSS combine <u>Science and Engineering Practices</u> with <u>Core Ideas</u> and <u>Crosscutting Concepts</u>. 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 <u>science</u>, NGSS focuses on core ideas in <u>engineering</u>, the <u>nature of science</u>, and the connection among <u>science, technology, society, and the environment</u>.
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
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.

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.

K.Forces and Interactions: Pushes and Pulls

K.Forces and Interactions: Pushes and Pulls

Students who demonstrate understanding can:

K-PS2-1. Plan and conduct an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object. [Clarification Statement: Examples of pushes or pulls could include a string attached to an object being pulled, a person pushing an object, a person stopping a rolling ball, and two objects colliding and pushing on each other.] [Assessment Boundary: Assessment is limited to different relative strengths or different directions, but not both at the same time. Assessment does not include non-contact pushes or pulls such as those produced by magnets.]

K-PS2-2. Analyze data to determine if a design solution works as intended to change the speed or direction of an object with a push or a pull.* [Clarification Statement: Examples of problems requiring a solution could include having a marble or other object move a certain distance, follow a particular path, and knock down other objects. Examples of solutions could include tools such as a ramp to increase the speed of the object and a structure that would cause an object such as a marble or ball to turn.] [Assessment Boundary: Assessment does not include friction as a mechanism for change in speed.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations Planning and carrying out investigations to answer questions or test solutions to problems in K–2 builds on prior experiences and progresses to simple investigations, based on fair tests, which provide data to support explanations or design solutions. ▪ With guidance, plan and conduct an investigation in collaboration with peers. (K-PS2-1) **Analyzing and Interpreting Data** Analyzing data in K–2 builds on prior experiences and progresses to collecting, recording, and sharing observations. ▪ Analyze data from tests of an object or tool to determine if it works as intended. (K-PS2-2) --- ***Connections to Nature of Science*** **Scientific Investigations Use a Variety of Methods** ▪ Scientists use different ways to study the world. (K-PS2-1)	**PS2.A: Forces and Motion** ▪ Pushes and pulls can have different strengths and directions. (K-PS2-1),(K-PS2-2) ▪ Pushing or pulling on an object can change the speed or direction of its motion and can start or stop it. (K-PS2-1),(K-PS2-2) **PS2.B: Types of Interactions** ▪ When objects touch or collide, they push on one another and can change motion. (K-PS2-1) **PS3.C: Relationship Between Energy and Forces** ▪ A bigger push or pull makes things speed up or slow down more quickly. *(secondary to K-PS2-1)* **ETS1.A: Defining Engineering Problems** ▪ A situation that people want to change or create can be approached as a problem to be solved through engineering. Such problems may have many acceptable solutions. *(secondary to K-PS2-2)*	**Cause and Effect** ▪ Simple tests can be designed to gather evidence to support or refute student ideas about causes. (K-PS2-1),(K-PS2-2)

Connections to other DCIs in kindergarten: **K.ETS1.A** (K-PS2-2); **K.ETS1.B** (K-PS2-2)

Articulation of DCIs across grade-levels: **2.ETS1.B** (K-PS2-2); **3.PS2.A** (K-PS2-1),(K-PS2-2); **3.PS2.B** (K-PS2-1); **4.PS3.A** (K-PS2-1); **4.ETS1.A** (K-PS2-2)

Common Core State Standards Connections:

ELA/Literacy –

RI.K.1 With prompting and support, ask and answer questions about key details in a text. *(K-PS2-2)*
W.K.7 Participate in shared research and writing projects (e.g., explore a number of books by a favorite author and express opinions about them). (K-PS2-1)
SL.K.3 Ask and answer questions in order to seek help, get information, or clarify something that is not understood. *(K-PS2-2)*

Mathematics –

MP.2 Reason abstractly and quantitatively. *(K-PS2-1)*
K.MD.A.1 Describe measurable attributes of objects, such as length or weight. Describe several measurable attributes of a single object. *(K-PS2-1)*
K.MD.A.2 Directly compare two objects with a measurable attribute in common, to see which object has "more of"/"less of" the attribute, and describe the difference. (K-PS2-1)

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/
  → *View classroom tasks:* http://bit.do/ngsstasks *and evidence statements:* http://bit.do/ngss-ev
- 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.

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

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

GUIDING BELIEFS FOR AN EQUITABLE SCIENCE LEARNING ENVIRONMENT

Equitable instruction starts with knowing the students in your classroom.

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.

It is essential to hold high expectations for all students.

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.

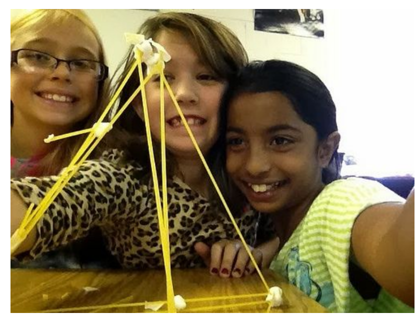


Photo Courtesy Wesley Fryer

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.

Photo Courtesy DoDEA Communications

INSTRUCTIONAL SHIFTS FOR EQUITABLE SCIENCE LEARNING

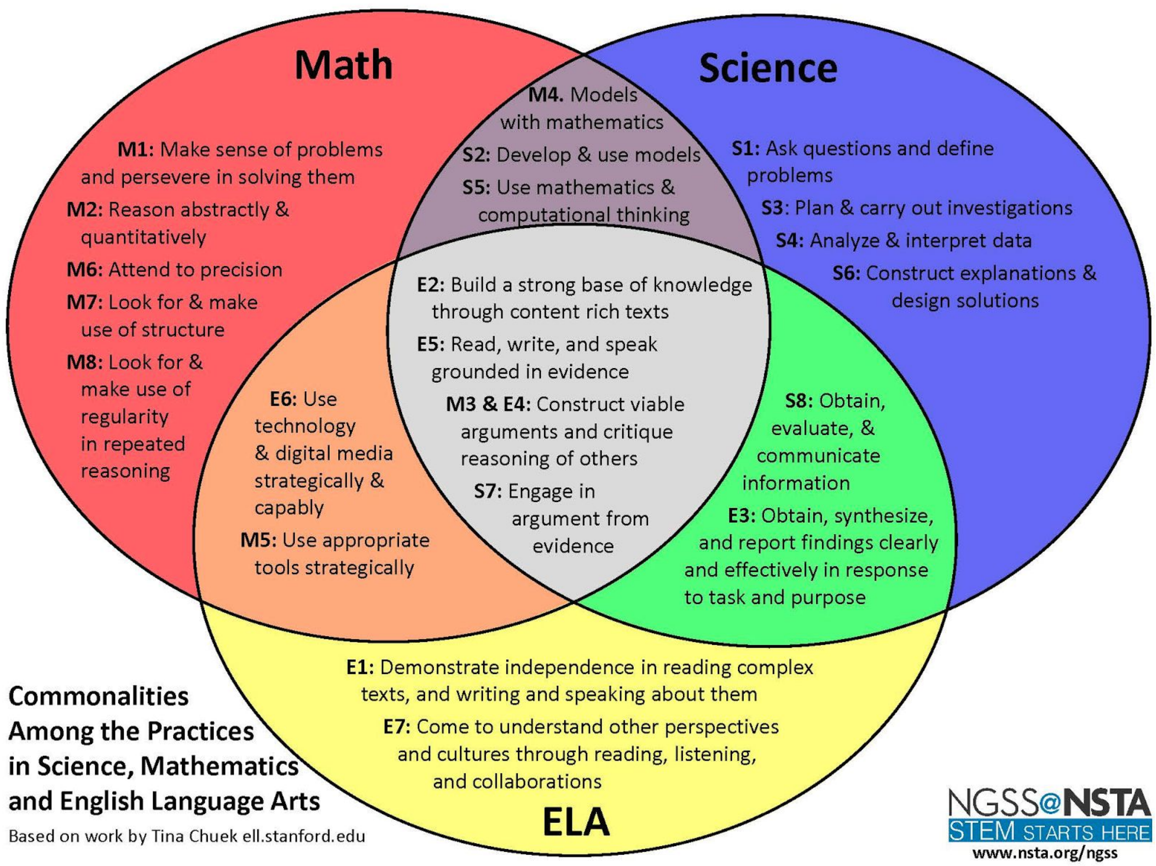
FROM LESS EQUITABLE SCIENCE TEACHING	TO MORE EQUITABLE SCIENCE LEARNING
frontloading vocabulary and content followed by a confirmation lab	facilitating common concrete experiences with connected language and sense-making
having low expectations for some students	having high expectations for each student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

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*** (emphasis added)." — STEM Teaching Tool #21

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



→ *Read more:* http://bit.do/ngss-ccss

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

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.

SHARED INSTRUCTIONAL PRACTICES	
1. Determine Meaning	**5. Construct Claims From Evidence**
2. Interpret Meaning	**6. Research**
3. Exchange Information	**7. Evaluate Arguments**
4. Respond to Complex Texts	**8. Adapt for a Purpose**

→ *Read more:* http://bit.do/practice-matrix

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

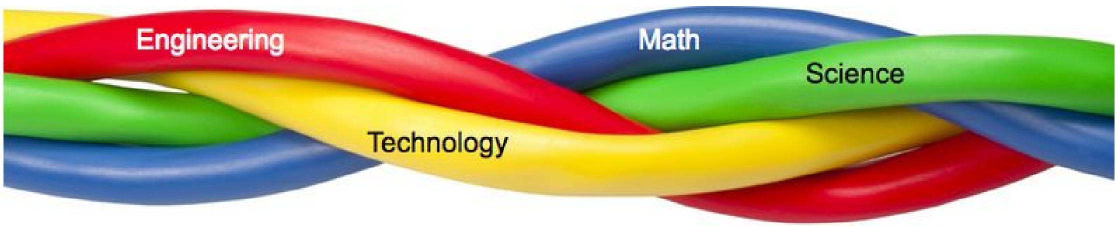
INTEGRATED STEM UNITS PROVIDE OPPORTUNITIES TO APPLY CORE INSTRUCTION

"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.

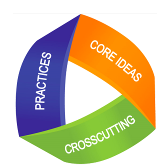


"Applying mathematics during engineering design challenges can help children develop critical thinking, problem solving, and communication skills."
— Teaching Children Mathematics

→ *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

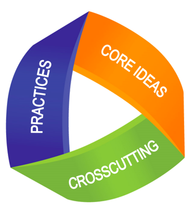
→ *Access professional development on argument writing:* http://bit.do/ngss-argument

NGSS Playbook: The Importance of High-Quality Assessments

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

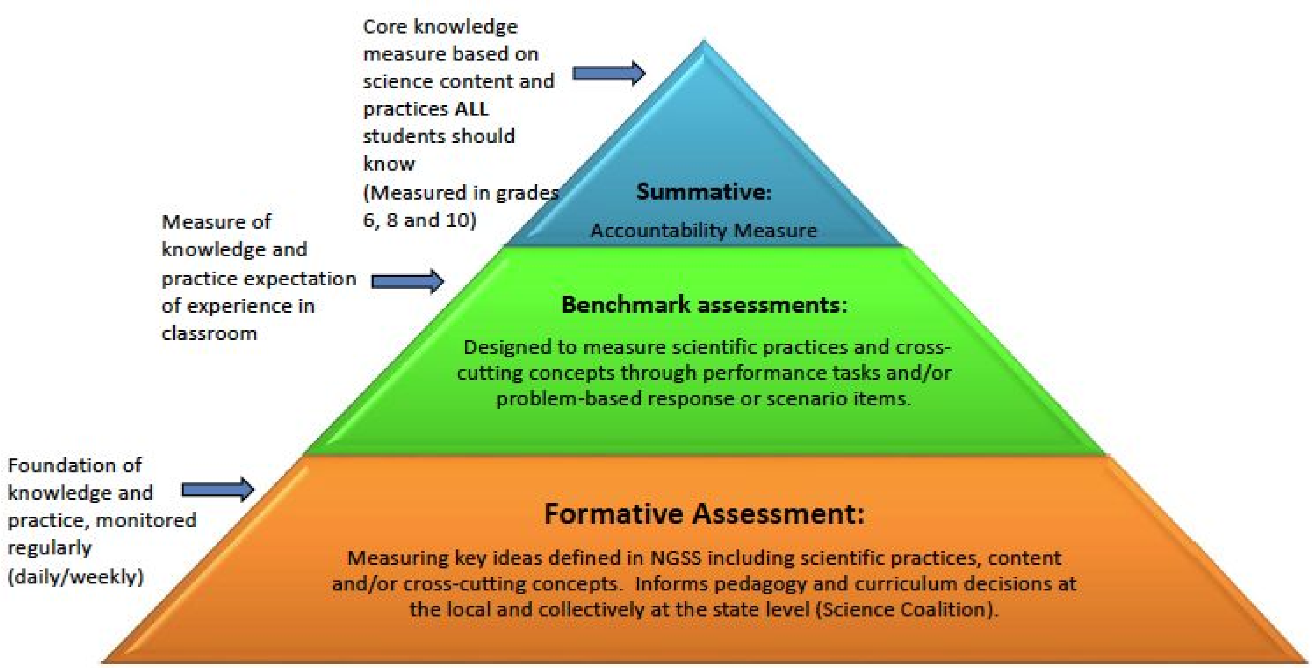
ASSESSING THREE-DIMENSIONAL LEARNING



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



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.

→ *Read more:* http://www.ode.state.or.us/search/results/?id=240
→ *View a sample Smarter Balanced Performance Task:* http://bit.do/perf-task
→ *View sample NGSS Classroom Tasks:* http://bit.do/ngss-tasks

SHIFTS IN ASSESSMENT AND INSTRUCTION

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

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*