Chapter 2: Define Your Aspiration

Questions from Diagnostic Tool

- Have we articulated a vision for what the NGSS will deliver for every student?
- Have we identified how the NGSS contribute to our vision for education and how adoption of the NGSS fits into our state's STEM plan?
- Have we identified how the NGSS contribute to our state's economic development strategy?
- Is that vision connected to our aspiration for college and career readiness across the state, including efforts to implement the CCSS?
- Is that vision shared by a guiding coalition of state leaders, and are we doing enough to maximize the impact of their support?
- Does that vision coalesce around the connection between college and career readiness and science? If so, is that aspiration shared? Does the aspiration align with priorities within the system (policies, funding, etc.)?
- Can that vision be broken down into measurable goals for improving student outcomes and closing achievement gaps?

At first glance, aspirations may seem superfluous to the adoption and implementation of the NGSS. Leaders involved in change efforts know why they are making this change, but an aspiration is not a meaningful goal unless and until it is shared and held in common — by leaders, outside stakeholders and practitioners in the field. A shared aspiration must first be defined and articulated.

As noted in the introduction, the NGSS represent a major shift in the way science is taught in most classrooms. A shared aspiration will be important in your state's efforts to build the necessary coalition for adoption and, when the going gets tough, to persevere in implementation. Developing an aspiration, including the benefits of improved science education and performance for your state's students, will force you to develop your own deeper understanding of the NGSS — one that will anchor decisions about strategy and implementation down the road.

Action Steps

Step 1: Develop a vision for how the NGSS will affect students and your state.
Step 2: Understand what the NGSS will require.

Step 1: Develop a Vision for How the NGSS Will Affect Students and Your State

The NGSS will transform science instruction to make it relevant for students' lives — and ultimately improve science performance. Given the interest of policymakers, business and higher education to expand the STEM-capable workforce, the fact that you are undertaking the challenge to better prepare K–12 students for these options is likely to win you support. You need to be able to show where the NGSS can take your students. This vision is a critical piece of your case for adoption, and it will guide and shape your work in implementation.

A good vision for NGSS will answer five questions:

- What are we trying to accomplish for our students and why?
- How will we know that we have done it?
- What is holding us back from getting there?

- Why and how are the NGSS essential to our success?
- How do the NGSS fit into our overall STEM agenda and more broadly the economic development and growth agenda for our state?

What are we trying to accomplish for our students and why? Every state will have its own take on how best to answer this question, but a core principle is the vision that science competency unlocks the larger aspiration of college and career readiness. In fact, for many experts, the idea of college and career readiness simply cannot be separated from scientific literacy. With this in mind, the NGSS authors have developed a working definition of college and career readiness in science — shown in Figure 3 — which may be useful as you consider this question.

FIGURE 3: An Initial Draft Definition of College and Career Readiness in Science[2]

College- and Career-Ready Students can demonstrate evidence of:

- Applying a blend of Science and Engineering Practices, Crosscutting Concepts and Disciplinary Core Ideas (DCIs) to make sense of the world and approach problems not previously encountered by the student, new situations, new phenomena, and new information;
- Self-directed planning, monitoring and evaluation;
- Applying knowledge more flexibly across various disciplines through the continual exploration of Science and Engineering Practices, Crosscutting Concepts and DCIs;
- Employing valid and reliable research strategies; and
- Exhibiting evidence of the effective transfer of mathematics and disciplinary literacy skills to science.

This working definition of college and career readiness in science is based on the following assumptions:

- As indicated in *A Framework for K-12 Science Education*, students are expected to operate at the nexus of the three dimensions of science: 1) Science and Engineering Practice; 2) Crosscutting Concepts; and 3) DCIs.
- The learning expectations are equivalent for college and career.
- A student is ready to enter and succeed in coursework beyond high school in science and technical subjects that leads to a degree or credential. This includes the military and credentialing that can occur during the high school experience such as credentialing programs, dual enrollment programs and advanced placement courses.

And why do you want your students to be college and career ready in science? The reasons will vary from state to state, but here are some of the most common:

The economic imperative: The 21st century workforce continues to move toward one that demands an increased proficiency in science, technology, engineering and mathematics in all fields as well as traditional STEM fields. During the recession of the mid- to late 2000s, postings for STEM jobs outnumbered the STEM unemployed.[3] Even when the United States fills STEM jobs, businesses rely heavily on foreign-born workers to fill these positions rather than finding the skilled labor on the nation's shores. What's more, in the last 60 years, the percentage of foreign-born workers filling STEM positions has more than doubled — from 7 percent in 1950 to 17 percent in 2008.[4] Are there dominant industries in your state that depend on core science skill sets in their employees? Is it imperative that they be able to find the skilled high school and college graduates they need for these roles within your

[2] *APPENDIX C – A DRAFT Definition of College and Career Readiness in Science.* (Updated January 2013). Available at www.nextgenscience.org/sites/ngss/files/Appendix C - A DRAFT Definition of College and Career Readiness in Science - FINAL.pdf

[3] Change the Equation. (2012). *STEM Help Wanted: Demand for Science, Technology, Engineering and Mathematics Weathers the Storm.* Available at http://changetheequation.org/sites/default/files/CTEq_VitalSigns_Supply (2).pdf

[4] Carnevale, A.P., Smith, N., & Melton, M. *STEM.* (2011). Washington, DC: Center on Education and the Workforce.

state? What do your state's economic/job projection data say? What do your employers tell policymakers they need? What are your state's economic development ambitions? Remember that STEM jobs are not just for STEM graduates from four-year programs. Importantly, the number of STEM jobs is growing at every level, from postsecondary certification programs to those that require advanced degrees.

The competition imperative: Regardless of the situation inside your state's borders, these changing requirements for careers are a global phenomenon. How important is it for your state to compete for these jobs? How important is it for your graduates, as other states and other countries improve their systems of science education, to meet this challenge?

The equity imperative: True scientific literacy has historically been the province of more privileged students — something reserved for the "gifted" rather than a requirement for all. We cannot close the college and career readiness gap without giving every student the opportunity to build his or her skills in scientific practices — practices that will apply both in and beyond STEM fields. White men still dominate the science and engineering workforce, accounting for 55 percent of those in science and engineering occupations. White women make up 18 percent of those employed in science and engineering occupations. Black men and women comprise just 3 percent of the scientists and engineers in science and engineering occupations; Hispanic men and women comprise just 4 percent.[5]

The informed citizen imperative: Science — and therefore science education — is central to the lives of all Americans, preparing them to be informed citizens in a democracy and knowledgeable consumers in a world fueled by innovations in science and technology.

How will we know that we have done it? Reflecting on the question of what you are trying to accomplish for your students and why will help you answer the question of how you will know you have done it. This is where you establish specific goals for science education in the context of your overall goals for education in your state. Simply defined, a goal translates the vision defined above into a series of specific measures. You do not need to get into detail about exact targets and dates at this point, but you need to establish goals that you know you will be able to measure and put numbers on in the future. Some examples of goals to consider:

- Increasing participation, scores and/or passage rates on third-party national assessments (e.g., Advanced Placement, International Baccalaureate and dual enrollment);
- Increasing course-taking and passage rates for rigorous science courses at the high school level;
- Improving National Assessment of Educational Progress science proficiency or proficiency on internationally benchmarked science assessments (e.g., the Trends in International Mathematics and Science Study);
- Increasing the number and percentage of high school graduates who enroll in postsecondary programs with the intent of acquiring a STEM credential or majoring in a STEM discipline;
- Increasing the number and percentage of high school graduates who begin careers in fields that require STEM knowledge and skills (many of which require some postsecondary experience but not a four-year degree);
- Increasing proficiency over time on science assessments aligned to the NGSS;
- Increasing the number and percentage of college graduates who graduate with majors in a scientific discipline;
- Closing equity gaps between disadvantaged students and their peers on any of the above measures; and

[5] National Science Foundation, Division of Science Resources Statistics. (2011). *Women, Minorities, and Persons with Disabilities in Science and Engineering: 2011.* Special Report NSF 11-309. Arlington, VA. Available at http://www.nsf.gov/statistics/wmpd/

- An index that aggregates and/or weights two or more of the above measures.

What is holding us back from getting there? Once you have established your goals, you are ready to reflect on the third question. What are the greatest areas of weakness in current practice and instruction? What deeply ingrained beliefs may impose a constraint? How will these things stand in the way of achieving the broad vision you have articulated?

Why and how are the NGSS essential to our success? The first three questions thus set up the problem that the NGSS are there to solve — and this question makes this solution explicit. From what you know about the NGSS, can you make the case for how they will help you confront the unique challenges your state faces? This is an opportunity to explain, in language that resonates in your state, why the conceptual shifts in the NGSS are essential to improving student performance.

How do the NGSS fit into our overall STEM agenda and more broadly the economic development and growth agenda for our state? The final key question to consider is one that will help place the NGSS within your state's broader STEM goals, including K–12, postsecondary, and economy- and business-related goals — thus improving the coherence of your state's STEM agenda across the pipeline.

For example, suppose that you know that engineering is a major jobs growth area for industries in your state and that, accordingly, your state has set a goal of doubling the number of high school and college graduates with engineering credentials. Going back to the conceptual shifts, you might realize that engineering is not a familiar concept in most of the major educator preparation programs in your state and that it is not emphasized in current K–12 coursework. Engineering literacy, then, has just become the watchword of your campaign for NGSS adoption and implementation because it is something that your state needs that the NGSS, properly implemented, can deliver.

EXERCISE 4: Articulate Your NGSS Vision

Objective(s) for participants:

- Answer the five key questions to develop the vision for what the NGSS will accomplish for students in the state.

Instructions:

- Consider the five key questions and any reference materials or evidence associated with each of them.
- Discuss each of the five questions in turn and record the answers on the flipchart template:
  - What are we trying to accomplish for our students and why?
  - How will we know that we have done it?
  - What is holding us back from getting there?
  - Why and how are the NGSS essential to our success?
  - How do the NGSS fit into our overall STEM agenda and more broadly the economic development and growth agenda for our state?
- Discuss and agree on a concise answer to each question.

Materials needed:

- Copies of questions to consider for each participant
- Flipchart paper
- Markers

Exercise notes:

- A great deal will depend on context and evidence to consider for each of the five questions.
- It will be critical for participants to bring information about their broader environment to consider. For example:
  - Public statements from policymakers about aspirations for the state (e.g., the governor's economic development agenda);
  - Strategic plans or visions developed for the state for college and career readiness in general and/or science in particular;
  - Studies and/or other research on the economic or business landscape in your state regarding STEM skills, current science standards and practices, etc.;
  - State-specific STEM plans; and
  - Documentation on the NGSS and the conceptual shifts.
- Consider splitting the team into groups to consider the five questions, and have the groups compare answers.
- Consider assigning the writing of "concise answer" statements to one person or a smaller team after the exercise is completed and general agreement is reached.

Template for Exercise 4

Question	Potential Answers
What are we trying to accomplish for our students and why?	
How will we know that we have done it?	
What is holding us back from getting there?	
Why and how are the NGSS essential to our success?	
How do the NGSS fit into our overall STEM agenda and more broadly the economic development and growth agenda for our state?	

Step 2: Understand What the NGSS Will Require

To effectively articulate an aspiration, your state strategic leadership team will need to be grounded in a clear understanding of the NGSS; what the standards require of students, educators and education systems; and how those requirements compare to what you are already doing in your state. This is not meant to be a "crosswalk" exercise, in which old standards are compared to new. *In fact, the NGSS are sufficiently different in architecture and demand that a traditional crosswalk would be meaningless.* Still, the question of how your state's old science standards compare to the new will be asked, and your state must be well prepared to respond. Understanding what the NGSS are, the overall shifts they will require, what will be most challenging for your state, and what the implications will be for both adoption and implementation is critical. Ironically, the things that may be hardest (e.g., integrating practice and content) will also be the things that create the most value for your students; as such, they will become a key part of the case that you make for adoption.

So what is different about the NGSS? Figure 4 gives a summary; for more in-depth information, go to the NGSS website at www.nextgenscience.org.

FIGURE 4: An Introduction to the NGSS

The overarching shift demanded by the NGSS is a change in the meaning of scientific proficiency. Students will demonstrate their proficiency in science not by recalling specific facts but by engaging in actual scientific practices that demonstrate the ability to apply scientific concepts and ideas in any context. Effective science teaching and learning comes from the combination of engaging in Disciplinary Core Ideas through Science and Engineering Practices, frequently in the context of Crosscutting Concepts. As such, the NGSS are organized around three dimensions:

- **Disciplinary Core Ideas** that are acquired by students through an overall K–12 learning progression and can be taught at increasing levels of depth and complexity over time.
- **Science and Engineering Practices,** like developing and using models or analyzing and interpreting data, that are critical to scientific inquiry in any content area. These are not teaching strategies; they are a necessary student outcome to show proficiency in science.
- **Crosscutting Concepts,** like patterns and cause and effect, that provide the connective tissue between sciences. These concepts are found throughout all scientific disciplines and will be continually revisited and built on through the exploration of core content.

At their core, the NGSS are defined and set apart by their focus on the blending of these three dimensions and the coherence between them. A student who can demonstrate understanding of these three dimensions as portrayed as performance expectations is literate in science. An example of each is given below.

Sample Draft Kindergarten Standard PS1-a: Matter and Its Interactions		
Students who demonstrate understanding can: **K-PS1-a** **Design and conduct an investigation of different kinds of materials to describe their observable properties and classify the materials based on the patterns observed.** [Clarification Statement: Observations are qualitative only and could include relative length, weight, color, texture and hardness. Patterns include the similar properties that different materials share.]		
The performance expectation above was developed using the following elements from the National Research Council's 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, design and conduct investigations in collaboration with peers. ▪ Make direct or indirect observations and/or measurements to collect data which can be used to make comparisons. --- ***Connections to Nature of Science*** **Science Knowledge is Based on Empirical Evidence** ▪ Scientists look for patterns and order when making observations about the world.	**PS1-a: Structure and Properties of Matter** ▪ Different kinds of matter exist (e.g., wood, metal, water), and many of them can be either solid or liquid, depending on temperature. ▪ Matter can be described and classified by its observable properties (e.g., visual, aural, textural), by its uses, and by whether it occurs naturally or is manufactured.	**Patterns** ▪ Patterns in the natural and human designed world can be observed, used to describe phenomena and used as evidence.
Common Core State Standards Connections: *Mathematics* **K.MD.1** Describe measurable attributes of objects, such as length or weight. Describe several measurable attributes of a single object. **K.MD.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.		

How is this different from current science expectations in most states? The NGSS authors have defined six conceptual shifts that the standards require for faithful implementation:

- **K–12 science education should reflect the interconnected nature of science as it is practiced and experienced in the real world.** Most state and district standards express the three dimensions as separate entities, leading to their separation in both instruction and assessment. The NGSS expectations for both students and teachers are that they will engage at the nexus of these three dimensions, applying practices to content knowledge and making use of Crosscutting Concepts to do so.

- **The NGSS are student performance expectations — NOT curriculum.** The Disciplinary Core Ideas themselves form a progression of knowledge for students that is clearly laid out in the NGSS, but the Science and Engineering Practices and Crosscutting Concepts should not be limited to specific time periods of instruction. Rather, educators and students should return to the Science and Engineering

Practices and Crosscutting Concepts again and again, applying them to every Disciplinary Core Idea so that content knowledge progression is accompanied by skill development in the application of scientific practices and concepts. Simply said, the NGSS form the basis for student performance. Curriculum materials are state and local decisions that will encompass the order and day-to-day instructional needs to prepare students for the performances.

- **The science concepts in the NGSS build coherently from kindergarten through grade 12.** The focus on a few Disciplinary Core Ideas is a key aspect of a coherent science education. Historically, science education has been taught as a set of disjointed and isolated facts. The NGSS provide a more coherent progression aimed at overall scientific literacy, with instruction focused on a smaller set of ideas but with an eye on what the student should have already learned and what he or she will learn at the next level. These progressions for each grade band assume that the necessary previous material has been learned by the student.

- **The NGSS focus on deeper understanding of content as well as application of content.** Within the Disciplinary Core Ideas, the focus of the NGSS is on conceptual understanding — not just the facts that are associated with them. The facts and details are important evidence but can no longer be the sole focus of instruction. *A Framework for K-12 Science Education* casts this shift in terms of the difference between novices and experts: “Experts understand the core principle and theoretical constructs of their field, and they use them to make sense of new information or tackle novel problems. Novices, in contrast, tend to hold disconnected and even contradictory bits of knowledge as isolated facts and struggle to find a way to organize and integrate them.” The NGSS aim to make students experts rather than novices.

- **Science and engineering are integrated in science education from kindergarten through grade 12.** Unlike the traditional science disciplines, engineering has not routinely been included in state science standards, curricula or assessments or as a component of the education of new science teachers. The NGSS integrate engineering into the structure of science education by raising engineering design to the same level as scientific inquiry in classroom instruction and by giving core ideas of engineering and technology the same status as those in other major science disciplines.

- **The NGSS make explicit connections to the CCSS (English language arts/literacy and mathematics).** The release of the NGSS comes as most states are implementing the CCSS. This creates an opportunity for science to be part of a child’s comprehensive education. The NGSS take into account the content and performance expectations of the CCSS to ensure a symbiotic pace of learning in all content areas and specifically refer to related standards in the CCSS.

The NGSS are a product of both research and an understanding of best practices across states. Once your state understands the difference between your current standards and the NGSS and the conceptual shifts demanded, you can prioritize the biggest lifts for your state and articulate why these priorities will make the most difference for your students.

You may, for example, discover that your current standards’ core ideas are sufficiently focused, clear and sequenced, such that the transition to Disciplinary Core Ideas will be relatively easy. At the same time, however, you may find that the integration of scientific practices into this material, particularly engineering design, is completely absent from both the letter and practice of science education in your state. This will be a big shift — but it can also serve as a rallying point. The absence of real practices in science education, you can argue, will leave your students unprepared for careers in these fields. It is a gap in your state’s expectations that must be closed.

As you consider each of the shifts, it is helpful to focus on the implications for educator and student practice. Figure 5 gives some questions to consider.

FIGURE 5: Implications of NGSS Conceptual Shifts for Educators and Students

Shift	Questions To Consider
K–12 science education reflects the real-world interconnections in science.	• What do our current science standards require with respect to this shift (i.e., what is our baseline)? • Do our current science standards require students to demonstrate understanding by applying specific scientific practices and crosscutting concepts to core content knowledge and its acquisition? • Do our science educators emphasize this application in their expectations, instruction and assessment of students? • Do our schools and support systems facilitate collaboration among science educators to demonstrate the reach of scientific practices and crosscutting concepts across the core ideas in the disciplines? • Do we have a plan to ensure that our statewide summative science assessments are aligned to the NGSS?
All practices and crosscutting concepts are used to teach core ideas all year.	• Do our current science standards require students to build skills in scientific practices and crosscutting concepts by focusing on them — and connecting them to content — throughout each school year? • Do our science educators teach science practices and core concepts as a progression of core content rather than in addition to it? Do they use these practices and concepts to build in-depth student understanding in the context of the content areas covered throughout the school year? • Do our schools and support systems equip and encourage educators to plan their lessons in this way? • Do schools and teachers have access to the consumable physical materials (beyond textbooks/curriculum materials) to prepare and execute the classroom investigations and design work required by the NGSS?
Science concepts build coherently across K–12.	• Do our current science standards lay out expectations for student scientific knowledge as a progression across grades, or do they expect the same content (or unrelated content) to be taught across multiple years? • Do our science educators treat science content as a cumulative body of knowledge built year by year? Can they assess students' prior knowledge and take appropriate remedial action? • Do our schools and support systems emphasize the collaboration of educators across grade levels to ensure this progression of knowledge for their students?
The NGSS focus on deeper understanding and application of content.	• Do our current science standards expect students to master scientific core ideas and principles (e.g., "molecules are made up of atoms, and have different properties depending on their combination") and use them in multiple contexts, rather than memorizing particular facts or details with little or no context (e.g., "the molecule CO, carbon monoxide, is a poisonous gas")? • Can our science educators emphasize a deep understanding of core ideas,

	sometimes at the expense of particular details associated with those ideas? • Do our schools and support systems give educators what they need to keep coming back to and focusing on these Disciplinary Core Ideas?
Science and engineering are integrated in science education from kindergarten through grade 12.	• Do our current science standards require students to use engineering design ideas and practices alongside the traditional science disciplines from kindergarten through grade 12? • How comfortable are our current and candidate science educators with engineering design? Do they raise it to the same level as scientific inquiry as a core practice in science instruction? Do they give core ideas of engineering and technology equal weight with those in other disciplines? • Do our schools and support systems prepare our educators to teach engineering design and the core ideas of engineering and technology? Is this reflected in policy/funding for course offerings and their content?
Science standards coordinate with the CCSS in English language arts/ literacy and mathematics.	• Are our current and candidate science teachers aware of and knowledgeable about the CCSS? • Do our schools and support systems allow and encourage collaboration across scientific and nonscientific disciplines in the teaching of literacy, numeracy and science?

EXERCISE 5: Determine the Biggest NGSS Shifts for Your State

Objective(s) for participants:

- Arrive at a consensus on which NGSS conceptual shifts are more or less challenging for students and educators in the state.

Instructions:

- Individually read through and reflect on the "questions to consider" in Figure 5.
- Discuss and come to consensus on which one to two shifts represent the *heaviest lift* for the state and which one to two shifts represent the *lightest lift.*
- Using the flipchart template, discuss and record reflections on the shifts that are the *heaviest lift:*
    - Why are these shifts the *heaviest lift,* and what are potential leverage points to intervene?
    - What would happen if we successfully made these shifts?
    - How can we use these areas of relative weakness to make the case for NGSS adoption?
- Using the flipchart template, discuss and record reflections on the shifts that are the *lightest lift:*
    - Why are they the *lightest lift*?
    - How can we use these areas of relative strength to build momentum for NGSS adoption?

Materials needed:

- Copies of questions to consider for each participant
- Flipchart paper
- Markers

Template for Exercise 5

Shift	Heavy or Light Lift and Rationale for Why	For Heavy Lifts, Impact If We Successfully Make These Shifts	For Heavy Lifts, Areas of Relative Weakness To Make the Case for NGSS Adoption	For Light Lifts, Areas of Relative Strength To Build Momentum for NGSS Adoption

Conclusion

As noted at the beginning of this chapter, an aspiration may seem trivial, but it is critical. It is arguably the cornerstone of your case for adopting the NGSS. Moreover, it is the foundation for your entire implementation plan. An aspiration will keep your end goal at the forefront and will focus your efforts. With a clear aspiration in hand, you are ready to dig into your state's current and previous performance in science and to use this information to set a baseline for the work ahead.