

○ F R A M E W O R K

for Leading  
Next Generation  
Science Standards  
Implementation

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# Introduction

The innovations in the Next Generation Science Standards (NGSS; NGSS Lead States, 2013a) require shifts in science teaching and learning that are different from the approaches called for in prior science education standards (Bybee, 2015; NRC, 2012; Reiser, 2013). These innovations, or conceptual shifts, reflect a new vision for K–12 science education and include:

- Science learning that is three-dimensional, connecting disciplinary core ideas (DCIs), science and engineering practices (SEPs), and crosscutting concepts (CCCs).
- Student engagement in explaining phenomena and designing solutions.
- Learning experiences that connect engineering design and the nature of science with the three dimensions of the NGSS.
- Coherent progressions of SEPs, DCIs, and CCCs from kindergarten to high school.
- Connections made between science, English language arts, and mathematics. (Bybee, 2015; NGSS Lead States, 2013b, pp. 1–4)

As of spring 2017, 18 states plus the District of Columbia have adopted the NGSS as their state science education standards, and 15 states have adapted their state standards to align with the *Framework for K–12 Science Education* (NRC, 2012) and the NGSS. In addition, six states are developing new state science education standards based on the NGSS, and numerous school districts are either adopting or adapting the NGSS. The implications for the students in our country are impressive — as of 2017, more than 50 percent of all students in the United States will be engaged in science learning that reflects the innovations and vision of the NGSS (Bybee & Chopyak, 2017).

The innovations of these standards pose new challenges for teachers and students, as well as for educators charged with leading the implementation of the new standards. Promoting science achievement, access, and equity for all learners that align with the new vision requires that states, districts, and schools have the leadership to guide the implementation of new standards. The primary role of these leaders will be to support educators in learning the standards and shifting their curriculum, instruction, and assessment practices. They will also need to address and overcome significant challenges to ensuring that all students have guaranteed and equitable access to rigorous standards-based curriculum and teachers who use standards effectively.

Unlike in previous science education reform initiatives, the innovations in the NGSS necessitate significant transformations and shifts in practice. For example, the NGSS require shifts in what is taught, how it is taught, and how students engage in learning. In turn, making these shifts demands ample and sustained support and leadership. Implementation of the NGSS will require champions at the state and local levels who clearly understand the vision of the NGSS and the innovations called for and who have the capacity to expand the commitment to the NGSS among key stakeholders. State leaders will need to make the policy environment fertile for these new standards to take hold. Local leaders must learn to create strong professional learning systems that build the capacity of educators to transform science teaching and learning and create and scale up the use of NGSS instructional materials.

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## The Development of the *Framework for Leading Next Generation Science Standards Implementation*

In response to the need to develop leaders to guide the implementation of the NGSS, the Carnegie Corporation of New York provided funding to WestEd to develop a framework that defines the leadership knowledge and actions needed to effectively implement the NGSS. The development of the framework entailed completing a review of the literature to identify the leadership knowledge and actions necessary for implementing new standards; convening an NGSS Leadership Summit with 21 national science education experts who have been implementing the NGSS in states and districts; and conducting 23 interviews with leaders at all levels of the system in California and Washington to gather voices from the field (many of which are included in quotations throughout this framework document). The *Framework for Leading Next Generation Science Standards Implementation* is a synthesis of information gathered from all of these activities.

One key learning from the project's review of the literature and work with national science education experts is the critical importance of situating the leadership for NGSS implementation within the overall educational system. For example, the National Science Teachers Association's (NSTA's) position statement on NGSS implementation reflects the nature of the systemic changes needed, stating that "achieving the goals of the NGSS will take a long-term systemic effort that requires significant changes in instruction, curriculum, assessment, teacher preparation and professional development, accompanied by extensive financial, administrative, and public support. It will also depend on all stakeholders at the local, district, and state level assuming a shared and collaborative responsibility for helping realize the goals of NGSS" (NSTA, 2016, p. 2).

In addition, the project identified the organizations, documents, and resources that science education leaders are accessing to support their strategic implementation of the NGSS and NGSS-aligned standards, such as the documents available through Achieve, NSTA, the National Academies, the National Association of State Boards of Education, and several states' websites. There are a multitude of documents available to leaders to inform and guide their strategic planning and implementation (e.g., *Next Generation Science Standards District Implementation Workbook* [Achieve, 2017]). Throughout the *Framework for Leading Next Generation Science Standards*

*Implementation*, we provide links to many of these resources to guide leaders in their development of plans to implement the NGSS.

The literature review and analyses of several resources on education leadership provided a wealth of information regarding the foundational knowledge that leaders need in order to guide and lead educational improvements, including the implementation of standards. However, no guidance was found regarding what knowledge is needed by leaders in order to drive the transformations that are required by the implementation of the NGSS, let alone how such knowledge would be developed. While leaders must have a deep understanding of the standards, that knowledge alone falls short of what leaders need to know and be able to do to support educators in making the necessary shifts in teaching, learning, and assessing that the NGSS requires.

In response to this gap in the literature, project leaders convened national science education and NGSS leaders in a summit to contribute to the identification of the foundational knowledge needed to lead the implementation of the NGSS. Further, project leaders conducted in-depth interviews with science education leaders in two states that have been implementing the NGSS for several years.

Through this process, six foundational knowledge areas were identified as essential in supporting leaders to coherently and systematically implement the NGSS. These knowledge areas form the Leadership Knowledge domain of the framework. Additionally, project leaders identified three other domains for the successful implementation of the NGSS: Critical Actions, Impacting NGSS Teaching and Learning, and Sustaining Implementation of NGSS. These four domains have been developed into the *Framework for Leading Next Generation Science Standards Implementation*. The framework is intended to fill a gap by focusing on what leaders need to know and do to guide and sustain the implementation of the NGSS. The framework is graphically represented and described in detail in the next section.

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## Values Shared by the Developers of the Framework

In the NGSS Leadership Summit, science education experts and project staff were convened to develop this framework. We began by examining and discussing the beliefs and values we share that guide our work in science education. Through these discussions, we identified the following values and beliefs that underlie the *Framework for Leading Next Generation Science Standards Implementation*.

1. **Equity for all students is fundamental in science education.** All students should have access to an education that prepares them to be successful and to become lifelong learners, including being producers and consumers of scientific information. All students have the capacity to succeed and thrive if given the opportunities to fully engage with the innovations in the NGSS in a learning environment that is student-centered where they are provided with equitable, engaging, rigorous, and coherent opportunities to explore phenomena and learn science relevant to their lives. Ensuring equitable access requires educators to create the cultural and local relevance for students to engage in the practices and to understand the ideas of science. Leaders and educators, therefore, must recognize areas where inequity exists and find solutions to address the inequity.

2. **Leadership is essential for guiding science education improvements and implementing the NGSS.** Leaders need to engage in effective leadership practices, work collaboratively across levels of the system, and participate in professional learning experiences to deepen their knowledge and capacity. Leaders working together to achieve sustained implementation of the NGSS need to share a common vision, develop a common language, and understand the roles and responsibilities that each leader brings to the work. It is essential that leaders develop deep fluency in the language and concepts of the NGSS (NGSS Lead States, 2013a), the NGSS appendices (NGSS Lead States, 2013b), and the *Framework for K–12 Science Education* (NRC, 2012).
3. **Engaging in the three dimensions of learning science is foundational for achieving the vision of the NGSS.** Science is both a body of knowledge and a way of knowing about the natural world. Teachers and students need to approach the learning of science as scientists. Learners should have opportunities to learn by actively engaging in the science and engineering practices, making sense of their observations through generating explanations, and thinking critically. Learners should also have opportunities to learn by using the crosscutting concepts that set the context for asking the right questions in order to be productive in problem-solving. Those questions are essential to building strong knowledge structures. The diverse knowledge and skills that learners bring as members of different cultural groups provide rich perspectives and are assets upon which new understandings can be built. Understanding science and engineering content and practices provides agency and affordances that are strengthened by diverse ideas and perspectives.
4. **Effective teacher and leader professional learning is imperative.** All educators and leaders should have opportunities to engage in high-quality professional learning that deepens their knowledge and builds their capacity. Ensuring equitable opportunities for professional learning requires recognizing and identifying where inequities exist, such as teachers who live in remote or rural areas with little access to some types of professional learning and potentially limited internet access. Leaders who design, implement, facilitate, and evaluate professional learning for others need to understand adult learning theories, enact the *Standards for Professional Learning* (Learning Forward, 2011), and have opportunities to develop as facilitators.
5. **Building capacity, engaging in networks, and collaborating are essential for sustaining the implementation of the NGSS.** The relationships that are built as a result of collaboration, communication, and sharing of knowledge are foundational to the NGSS implementation process. Building communities of practice among teachers and among leaders can contribute to sharing the knowledge that they are generating and the resources that they are developing, and contributes to building the human capital needed to implement the NGSS. Collaborating and engaging with key stakeholders, both nationally and in local contexts, contributes to building capacity for NGSS implementation.
6. **Both understanding and leading the change process for individuals and organizations are fundamental to implementing the NGSS.** Change management requires knowledge of the change process and requires differentiated strategies for people who have varying comfort levels with change. Leading the kind of changes that are driven by the innovations in the NGSS requires ensuring that people and organizations receive the ongoing support to enable them to make

changes in practice over time. For NGSS implementation to be successful, all educators and leaders will need to be drivers of change.

7. **The implementation of the NGSS needs to be systemic and coherent.** Science education should not exist in a vacuum, nor should the learning of science be isolated from other disciplines. Leaders need to consider ways to align and integrate science with the learning of other subjects. Science learning can also occur anywhere and outside of school hours. In order to transform science education, leaders need to involve and consider the many contexts for science learning, including the community and informal environments that engage students and their families in learning science.

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## Suggestions for Engaging with the Framework

The purpose of the *Framework for Leading Next Generation Science Standards Implementation* is to provide a comprehensive vision of the leadership knowledge necessary and the critical actions that need to be taken to plan for and implement the NGSS. Depending upon your leadership role, the framework can be used in a variety of ways to inform policy and practice. Below, we identify potential uses of the framework for state and local leaders and for those who develop leaders focused on the implementation of the NGSS.

For state and local leaders, we suggest the following uses of the framework:

- Use the framework to inform your initial NGSS planning, or to reflect on and possibly revise existing NGSS implementation plans.
- Review the descriptions of the leadership knowledge areas and engage in a self-assessment to identify your strengths and gaps in knowledge for planning, implementing, and sustaining the NGSS. Consider which areas you may want to learn more about in order to enhance your leadership knowledge.
- Share the framework with the team or colleagues you are working with to plan NGSS implementation. Use the framework to create a shared vision of the leadership knowledge that you all need, the critical actions you will need to take, the system drivers to influence, and actions and data needed to support sustainability. Discuss as a team where you have strengths and what you would like to learn.
- Use the framework to develop state education agency (SEA) guidance documents for schools and districts to use in the implementation of the NGSS as well as for the development of requests for proposals around science education and the assessment of proposals from local education agencies (LEAs).
- Engage SEA colleagues from other states in deepening their understanding of the framework and how its use might spark cross-state collaboration around the implementation of the NGSS. Similarly, convene colleagues from other LEAs to collaboratively engage with the framework as a catalyst for cross-district networking.
- Present and discuss the framework at state and regional science coordinators' meetings to build capacity for leading the NGSS.

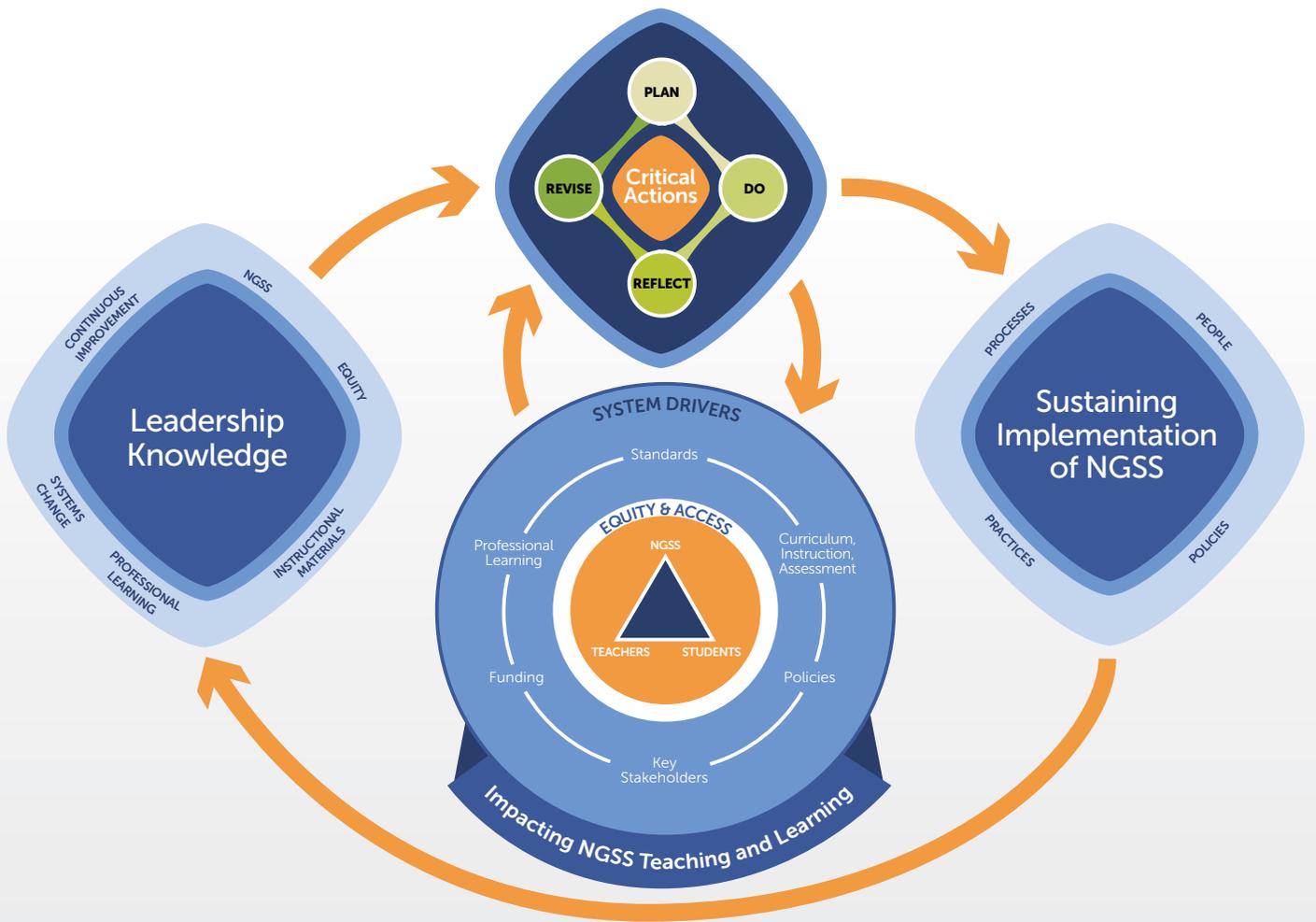
For developers of leaders, we suggest the following uses of the framework:

- Use the framework as a guideline for developing course curricula for leaders in the six foundational knowledge areas identified in Domain 1 of the framework.
- Engage current leaders with the framework as a tool to reflect on their knowledge and actions and to consider ways to refine what they know and do to lead the implementation of the NGSS.
- Engage new leaders in assessing their understanding of the leadership knowledge and in setting learning goals for themselves.
- Teach new leaders to understand the system drivers that they must influence or consider in order to enact the NGSS in the classroom.
- Consider the four domains of the framework in designing and implementing professional learning opportunities for leaders around NGSS implementation.



# Overview of the Framework

Figure 1. Framework for Leading Next Generation Science Standards Implementation



The *Framework for Leading Next Generation Science Standards Implementation* answers the question: What do leaders need to know and be able to do in order to lead the implementation of the Next Generation Science Standards (NGSS)? It provides a vision of the four major domains that leaders focus on as they lead the implementation of the NGSS.

As discussed earlier, the innovations in the NGSS require significant transformations and shifts in practice. For example, students will be engaged in three-dimensional learning, explaining phenomena and designing solutions, and developing their science knowledge and understanding through a progression of learning from kindergarten to high school. These innovations, or conceptual shifts, reflect a new vision for K–12 science education.

The shift in what and how students engage with and learn science has significant implications for the instructional shifts that also need to occur to ensure student learning. For many teachers, the shifts will demand using a variety of instructional strategies and approaches that require additional professional learning and coaching support. At the same time, other aspects of the system will need to be aligned to support these transformations in teaching and learning. It is imperative to look at the teaching conditions necessary for successful implementation of the NGSS. For example, professional learning and evaluation systems will need to reflect what teachers need to know and be able to do to effectively implement the NGSS. School leaders will need to examine the structure of the school day to ensure adequate time is available for science teaching and learning. Developing and supporting teacher leaders to ensure sustainable coordination and implementation of the NGSS will also be essential.

These transformational changes in practice require ample and sustained support from leaders. A fundamental concept within the framework is that leadership for the NGSS requires leaders to develop and use new knowledge unique to the NGSS. Further, the framework assumes that possessing this leadership knowledge is a necessary ingredient for leaders to be able to carry out the critical actions needed for NGSS implementation. The framework lays out the knowledge and critical actions that leaders need to successfully implement the NGSS.

*"I'm sobered by the complexity of NGSS implementation and energized by the potential. There's a lot of value in having the three dimensions and that has caused us to be much more focused on talk and modeling, more so than when we were inquiry focused. We are more focused on various ways of coming to make meaning of phenomena, and argumentation from evidence is more emphasized. These practices are an important aspect of doing inquiry that the NGSS emphasizes, and it's all about making sense with intertwining the DCIs. The focus is on modeling and argumentation as two specific ways to communicate about the phenomena. Inquiry was always about sense-making, but the process skills didn't have the same impact. Now, it's integrated in a way that it's part of the process. When you see the young children develop their models and explain them to you, the thinking and the reasoning that is going on is so powerful. It's inspiring. How do I get my kids there? How do I get my kids to do the thinking and the reasoning? It's articulated well in the NGSS."*

— *Informal Science Education Institution Leader*

The framework starts with **Domain 1: Leadership Knowledge**. This domain consists of six foundational knowledge areas that leaders need to know and understand in order to prepare them to lead NGSS implementation:

- NGSS and the Innovations in NGSS
- Equity and Access for All Learners
- Instructional Materials, Curriculum, and Assessment
- Professional Learning
- Systems Change
- Continuous Improvement

The six leadership knowledge areas directly inform and influence all of the actions that leaders take in **Domain 2: Critical Actions**. These actions are:

- Aligning Policies
- Allocating Funding
- Assessing the System
- Building a Shared Vision
- Designing and Implementing Professional Learning for Teachers and Leaders
- Developing Communication Strategies
- Engaging Families and Key Stakeholders
- Focusing on Equity and Accessibility
- Forming Implementation Teams
- Selecting, Adopting, Developing, and Aligning Curriculum, Instructional Materials, and Assessments
- Using Data and Research to Monitor and Improve

Leaders implement all of these critical actions using a continuous improvement cycle of Plan-Do-Reflect-Revise.

The need for ongoing interaction and integration between Domains 2 and 3 is critical to the continuous improvement process that is inherent in leading the implementation of the NGSS. **Domain 3: Impacting NGSS Teaching and Learning** emphasizes that the focus of NGSS implementation should always be on standards-based teaching and learning in the classroom for all students. At the center of this domain is the vision of the standards in use in the classroom, influencing the interactions among teachers, NGSS, and students (Ball & Cohen, 2000). The circle encompassing the classroom emphasizes that all students are engaged in NGSS learning and have equitable opportunities and access to learn science. Surrounding this center are six system drivers that most influence the use of the NGSS in classroom practice. The critical actions

that leaders take to implement the NGSS are both informed by and focused on the six system drivers. As leaders implement the NGSS implementation plans and engage in continuous improvement, they gather data to gauge the extent to which their actions are influencing and leveraging each of the system drivers and contributing to the achievement of their goals. This ongoing interaction between leaders' critical actions and their focus on the impact on NGSS teaching and learning is represented by the two arrows connecting these two domains in the graphic representation of the *Framework for Leading Next Generation Science Standards Implementation* (Figure 1). The six system drivers are:

- Standards
- Curriculum, Instruction, and Assessment
- Policies
- Key Stakeholders
- Funding
- Professional Learning

**Domain 4: Sustaining Implementation of NGSS** represents the overall goal of leaders' work. In this domain, leaders are continuously assessing whether they have achieved effective implementation and what is needed next to ensure sustainable implementation. Based on their cycle of continuous improvement, the leaders gauge the extent to which they are moving toward sustainable implementation of the standards. They may determine that they need to further enhance their own knowledge and then refine their use of the critical actions to more effectively implement the standards. Specifically, in the fourth domain, leaders examine their impact on four key areas that influence sustaining the use of the NGSS:

- People
- Policies
- Processes
- Practices

The framework's four domains work together and overlap in many ways. The following sections of this document provide more detail on each of these domains of the *Framework for Leading Next Generation Science Standards Implementation*. The framework is intended to inform the work of all leaders at all levels of the system — from teacher leaders to district leaders to state education leaders — who are charged with supporting and implementing the NGSS. The framework can be used as a self-assessment for leaders to identify areas for their further development to prepare them to lead standards implementation and as a planning guide to help leaders think through the critical actions that they need to take in order to lead and support others for NGSS implementation. Further, it can focus leaders on the specific drivers that need their attention.



# Domain 1: Leadership Knowledge

Figure 1.1. Leadership Knowledge



In order to effectively lead the implementation of the NGSS or other state science education standards that are closely aligned to the NGSS, leaders need in-depth knowledge within six distinct, but related knowledge bases (Figure 1.1).

Each knowledge base contains the specific content that leaders need to guide implementation of the NGSS. Collectively, the six knowledge bases work together to inform how leaders approach and support implementation of the NGSS.

*"If you find you miss some layer of knowledge, you have to go back — be patient and it will pay off. You cannot skip anything — either in the process or in developing knowledge — and if something is missed, you just have to go back to it before any of this will be successful."*

*— Regional Science Coordinator*

Leaders need an understanding of the NGSS and the innovations embedded within the NGSS to advocate for the vision of science teaching and learning called for in the standards and to educate stakeholders about how the NGSS differ from prior standards. All leaders need to understand issues related to equity to ensure that policies promote and support equitable access to science learning for all students.

An understanding of what constitutes quality and coherent curriculum and instructional materials is needed to drive leaders' efforts to ensure high-quality alignment with the standards. Knowledge of effective professional learning informs the ways in which leaders support educators to learn to use the standards in their schools and classrooms. Leaders also need to know and apply research on systems change and improvement science. To ensure sustainability of the changes in teaching and learning, leaders must engage in continuous improvement cycles and use data to inform those improvements.

*"It is essential for leaders to be able to explain the NGSS. They need to know what they're leading and how to provide the support needed to teach the NGSS. And it is important to know what NGSS implementation looks like in the classroom. They need to know the change process and how to deal with resistance. This is just much too complicated to wing it."*

*— Higher Education Science Education Faculty*

Where leaders sit within the system will shape how they think about and use the framework. Leaders at all levels of the system (e.g., state, district, school) need to develop their knowledge in each of the six areas and understand the intersections within and among all areas. However, the depth of knowledge needed may vary based on leaders' roles and the level of the system in which they work.

For example, leaders at the regional, district, or school levels who design and implement professional learning with science teachers will require a more in-depth understanding of the NGSS and how to design and facilitate professional learning. These leaders will also need to draw on their understanding of the processes of individual change and implementation to inform the plans for supporting changes in classrooms.

These leaders are often called upon to facilitate the adaptation of existing science instructional materials or to develop new instructional materials that are designed for NGSS, such as incorporating three-dimensional learning and engaging students in explaining phenomena and designing solutions. In these cases, leaders also need in-depth understanding of the innovations in the NGSS, the qualities of effective instructional materials, and how instructional materials align with their district or state curriculum frameworks.

“The biggest thing is not just stacking out content. There are performance expectations that drive the content. It takes a while to really understand the connection and the interaction. For example, it’s not just biology, but it’s biology to reach this specific performance expectation — what does that mean for a district, school, or student’s experiences in learning? We can’t go about business as usual with just a focus on content.”

— *District Science Coordinator*

State-level leaders’ understanding of the innovations in the NGSS needs to be thorough enough to enable them to advocate with key stakeholders and to develop a common vision among other leaders and educators, as well as ensure alignment of state-level policies to support the changes in teaching that are called for in the NGSS. For example, state-level leaders need to understand the characteristics and features of instructional materials and assessments designed for the NGSS in order to lead or inform the adoption or development of statewide assessments, lead the selection of instructional materials, and allocate funding to support NGSS implementation. In developing statewide NGSS implementation plans, these leaders also need to draw upon an understanding of the change process to inform the sequence of actions and supports that will be needed at different points in time during the implementation process.

What follows is a description of the specific understandings that all leaders need within each of the knowledge areas. Following the description of each knowledge area, we provide relevant reflection questions for leaders to consider.

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## NGSS and the Innovations in NGSS

An in-depth understanding of the NGSS includes knowing the research that underlies the standards and the *Framework for K–12 Science Education*, the conceptual shifts and innovations in the NGSS, and how these standards are different from prior science education standards. Delving into the NGSS to learn how they articulate student learning requires understanding of the student performance expectations and what students will know and be able to do by the end of each grade or grade band.

Leaders also need to understand the ways in which students engage in explaining phenomena and designing solutions, and the interconnections of the three dimensions in the NGSS: science and engineering practices (SEPs), disciplinary core ideas (DCIs), and crosscutting concepts (CCCs), and the connections to the nature of science and engineering, technology, and the application of science. Equally important is an understanding

of the K–12 learning progressions of SEPs, DCIs, and CCCs. Leaders' knowledge of the connections and alignment between the NGSS and standards for English language arts (ELA) and mathematics (Common Core State Standards [National Governors Association Center for Best Practices and Council of Chief State School Officers, 2010] or other state standards) supports the systemic implementation of the NGSS. All leaders also need to understand the architecture of the NGSS documents and how to navigate through the documents so that they can guide others in doing the same.

*"The NGSS is about what is going on in the real world. Science is about your ability to discover new knowledge and explain the natural world. You can be a scientist from day one — you don't have to wait to be a scientist. Investigations used to be merely simulations, but with the NGSS, students are fully engaged in doing and learning science."*

— *State Department of Education Leader*

## Leaders' Reflection Questions

- How well do you understand how the NGSS differ from prior science education standards? Identify a specific stakeholder group that you work with, and based on your current knowledge of the NGSS, write a coherent and complete advocacy message about the NGSS and why they are important. If you feel that there are gaps in your knowledge in order to perform this task, what might you do to deepen your learning of the NGSS?
- What is your current understanding of the conceptual shifts and innovations in the NGSS? What is your current understanding of three-dimensionality? Which aspects of the shifts, innovations, or the three dimensions might you need to learn more about?
- What is your current understanding of the performance expectations in the NGSS, including where they are located in the standards? How would you navigate through the NGSS to find specific information? What do you need to learn more about in terms of performance expectations and how to navigate the NGSS so that you can help others to do the same?

*"For me, this has been hugely different! I really did not use prior standards to drive my teaching — they were so light and really didn't provide any real insight into teaching science. I just trusted that our district and region made the right decision with the science kits, and I just took the curriculum and went from there. I trusted that kits addressed the standards. I didn't think about the standards, I just wrote deep learning targets for the units. I didn't even study them, I knew they were there, but they really were just in the background. But with the NGSS you have to study them and soak them up and see what they really mean. Totally different way of teaching — you are not going to get there casually, and you really have to study them. This has helped me think about how I engage other teachers in learning about the NGSS."*

— *Elementary School Teacher Leader*

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## Equity and Access for All Learners

Leaders need to engage with the NGSS case studies and discussions of the instructional practices for making science learning accessible to all students (NGSS Lead States, 2013b; <https://www.nextgenscience.org/appendix-d-case-studies>). They need to enhance their understanding of research-based instructional practices shown to be effective for various students, such as those who are economically disadvantaged, from different groups (racial, gender, ethnic), students with disabilities, English language learners, students in alternative education, and gifted and talented students. It is imperative that leaders understand the environmental, cultural, and familial contexts of a wide range of students and how to meet students' diverse needs in ways that build on students' strengths (Lee & Buxton, 2010). Leaders need to understand the connections between and among science, literacy, and mathematics, and how these connections support all students in developing mastery of the DCIs, SEPs, and CCCs (NGSS Lead States, 2013b, pp. 25–39).

Leaders need to be guided by an understanding of the research-based strategies for ensuring equitable access for all students to learn science in all schools and all classrooms (Research + Practice Collaboratory, 2015; National Research Council, 2012, pp. 277–297). Knowing the most current data on achievement gaps in science learning, based on results from international, national, state, and local assessments, provides leaders with the contextual understanding of their students' learning in science. It is also important for leaders to know the laws and policies addressing civil rights and educational access.

*"I really believe with my whole heart that we cannot realize the vision of the NGSS without explicit attention to equity. I have learned more about equity and have paid attention to what is changing in me and have seen my growth. Focusing on equity in the NGSS started this journey. One of our state's networking groups focuses specifically on equity and cultural responsiveness and uses it as a driver for learning and shaping advocacy messages. It is enormous to me now. My learning has changed me and the work I do, including my interactions with other people. I notice things differently, I speak up in ways that I had not before, and I strive to have an authentic voice. We need to change how we see students and begin to notice things — the hidden things — that block student learning."*

— *District Science Coordinator*

### Leaders' Reflection Questions

- What is your current awareness and understanding of the research-based teaching practices for making science learning accessible to all students? How have you engaged with the case studies in the NGSS to enhance your understanding? How have the cases impacted your thinking? If you have not yet engaged with the case studies in the NGSS, how might you do that, and how might you do so with stakeholders?
- What have you learned by examining the data on achievement gaps in science learning? How have you applied those findings to support your understanding

of which student populations in your own context are not reaching high performance levels? If you have not yet examined the data on achievement gaps in science learning, how might you do that, and how might you do so with stakeholders?

- What is your current understanding of the laws and policies on civil rights and educational access? Which laws and policies might you need to review to update your knowledge?

“Equity is a big challenge at the elementary level. Students get pulled out for intervention in the afternoon and it is right during science. And I just say ‘no’ and refuse to let any student be pulled out during science. We now have a science block mandated from the district, which is a huge step forward. There is a legal person in our district who said we were out of compliance and every child had to have access to science, and so our district made a science block. The argument was that all children have to have equitable opportunities to engage in science. The equity issue impacts the classroom. I never let any student leave for intervention, I am careful that resources and kits are accessible to every student, I pay attention to how I am asking questions of boys and girls, and I don’t want to leave out any disenfranchised students. White students are the non-dominant group in our district.”

— *Elementary School Teacher Leader*

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## Instructional Materials, Curriculum, and Assessment

In order to effectively lead NGSS implementation, leaders need to understand the ways that curriculum, instructional materials, and assessment support and guide instruction, including which strategies ensure their alignment. They need to deeply understand what the innovations in the NGSS look like in classrooms and which instructional approaches best support students’ learning of the NGSS (National Research Council, 2014). Building on these understandings, leaders also need to know and recognize the changes in curriculum, instructional materials, and assessment that are required to ensure effective implementation of the NGSS (National Research Council, 2012, pp. 241–277).

As leaders guide the curriculum selection, adoption, adaptation, and/or development processes, they need to know the features of quality science curriculum, instructional materials, and assessment uniquely designed for the NGSS, such as instructional materials that provide coherence across the three dimensions and that provide ways to monitor student learning across the three dimensions (BSCS, 2017). Similarly, leaders need to have awareness of and capacity to use or lead others to use the tools and resources that are available for evaluating the quality of science instructional materials and assessments designed for the NGSS, such as Achieve’s PEEC and EQuIP rubrics, and NextGen AIM by BSCS, WestEd, and Achieve (see Resources for Leaders).

"It is essential knowledge for leaders to understand unit design. In our regional professional network, we focus on designing units for the NGSS. It's not the lesson plan that is the fundamental structure, it's the unit. This idea is transformative for some people, and it makes a huge difference to teachers and how they teach. We've learned that a phenomena-driven unit results in real changes in teaching — how a lesson connects to the phenomena and the unit overall. This is critical for school administrators to understand — it's about the unit and not the lesson, because it influences how they approach teacher evaluation — they recognize that a one-day visit to a teacher's classroom fits within a larger picture of science teaching and learning."

— District Science Coordinator

## Leaders' Reflection Questions

- What strategies do you currently use to ensure alignment between instructional materials and assessments in science education? How effective are those strategies for ensuring alignment with the NGSS? What other strategies might you need to learn how to use to better analyze instructional materials and assessments for alignment to the NGSS?
- What is your understanding of what NGSS teaching and learning looks like in the classroom? What would you see the teacher doing to know that the teacher has expertise in implementing the NGSS? What would you see the students doing to know that students are engaged in the ways that are outlined in the NGSS? How, if at all, do you need to enhance your understanding?
- Which tools and processes do you currently use to select science instructional materials? How, if at all, do those tools and processes need to be adapted, or new tools identified, to enable you to lead the selection of instructional materials designed for the NGSS?

"The NGSS are complex, and even though we adopted them four years ago, there are teachers who might not move ahead with changes in the classrooms. Why? Because the statewide assessments are not yet aligned with NGSS teaching and learning. At the high school level, there is an end-of-course assessment in biology, so most high schools do integrate the NGSS into their biology courses, but only biology. Our state is moving to a new assessment for the NGSS in a year, and it will address all sciences — this is a huge transition, but one that is critical to ensure NGSS teaching."

— National Laboratory STEM Education Director

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## Professional Learning

Leaders at all levels of the system need to know the characteristics of effective, sustained professional learning for teachers and leaders, including Learning Forward's *Standards for Professional Learning* (2011). They need to understand the supports and constraints (from the state level to the local level) that impact the implementation of effective professional learning and the conditions that need to be in place to support widespread and effective professional learning for all educators. In order to lead effective professional learning for all teachers and all leaders, leaders need to understand the relevant research and the evidence-based practices for designing, implementing, facilitating, and evaluating professional learning (Desimone & Garet, 2015; Loucks-Horsley, Stiles, Mundry, Love, & Hewson, 2010; Wilson, 2013). Leaders who are responsible for developing facilitators of professional learning need to be aware of the most effective approaches for building the facilitators' capacity. Leaders need to develop their awareness of, and know how to continue accessing information about, the emerging and promising models of professional learning aimed at supporting NGSS implementation (Reiser, 2013).

"I always use a learning cycle in the professional learning that I develop — I use the 5E Instructional Model [Bybee, 2014], and it drives what I do for the design. I focus on the 'Engage' event to hook them and get them thinking as a learner and then scaffold their learning to discover their learning. They engage in a student-level experience and then scaffold their learning throughout the day. I'm very intentional about it. I rely on the learning cycle and pay attention to transitions. I have a storyline for the professional learning, I build a framework and activities using the 5 Es, and, most importantly, I know my audience."

— District Science Coordinator

### Leaders' Reflection Questions

- What is your current understanding of the research and literature about effective professional learning? How have you utilized the *Standards for Professional Learning* (2011) to enhance your knowledge? What, if anything, might you do to enhance your knowledge in this area? How do you use information from the research and literature in designing and implementing professional learning?
- What is your understanding of how to effectively design, implement, and evaluate professional learning for teachers? For leaders? What, if anything, might you do to enhance your knowledge in this area?
- What are your strategies for gaining information about new models for professional learning?

"We need principals as champions and leaders of this work. We have to help principals become more comfortable as science leaders — they have to believe in the NGSS themselves. They need to attend professional learning with their teachers so they get the tangible experience of what it's like to teach science this new way. We can also engage them in teaching science lessons — ask principals to teach a lesson and model to teachers that they are a learner too and that they are the 'lead learner' at the site. Principals also need to know the kinds of supports teachers need to implement the new standards, such as sustained professional development, the ability to visit each others' classrooms, coaching, co-teaching, curriculum and instructional resources, and the ability to be discriminating consumers of curriculum."

— *Foundation Program Officer*

## Systems Change

Leaders at all levels of the system need to know the research on individual, organizational, and systems change, and develop an understanding of the principles of systems change and how these principles inform the implementation of the NGSS. This area of knowledge includes the disciplines of systems thinking, knowledge management, team learning, problem solving, and adaptive leadership (Senge, Cambron-McCabe, Lucas, Smith, Dutton, & Kleiner, 2012). Leaders need to know how to apply the research on change to plan and lead the adoption and implementation of the NGSS and implementation of models for building community and fostering networks across the system. To support their application of knowledge, leaders need to know how to use the tools for designing, implementing, and evaluating change efforts, such as the Concerns-Based Adoption Model's tools on Stages of Concern, Levels of Use, and Innovation Configurations (Hall & Hord, 2015). Leaders need to understand how the underlying structures, patterns, and assumptions operating within organizations drive thinking and actions. Leaders also need to develop an understanding that change in behavior requires surfacing and changing assumptions and beliefs. Leaders of system change realize that interacting with interconnected systems is essential and that leaders focused on science education need to communicate with leaders of other content areas and with the public as well (Fullan & Quinn, 2016).

"In addition to understanding content and three-dimensional teaching, it is essential for leaders to know and have a complete understanding of the change process and how adults take on new learning. And how we, as leaders, support the changes."

— *Elementary School Principal*

## Leaders' Reflection Questions

- What change initiatives in the past have you had responsibility for leading? How did the research on systems change inform your work? What specific areas

of change management and systems thinking might be most helpful to you now as you lead NGSS implementation?

- How do you currently gather data and evidence of people’s concerns and their use of innovative practices? What is your current understanding of the Concerns-Based Adoption Model’s tools and how they could be used to support the implementation of the NGSS?
- What are some of the ways that you currently build community and foster networks among science education leaders? What additional knowledge might you need to enhance those efforts?

“Critical to this work is understanding change. We engage everyone — from all content areas — in the electronic version of the change game [The NETWORK Inc., 1999]. It supports them to look at their own context and they have to understand who their resisters are. Also, this is a three- to five-year process of change. You just cannot get it done in any less time — it won’t happen. You have to think systemwide. It’s been important for us to give teacher leaders permission to know it’s okay to not move fast and that going slow is best — go slow, do it well, identify what we can do next year to improve, where are your concerns, where is your school’s concern, are you moving too fast for your teachers — always provide resources and refer to the key learnings from the change game throughout the three to five years.”

— Regional Science Coordinator

## Continuous Improvement

Engaging in continuous improvement as leaders is essential to the successful implementation of the NGSS. It requires that they know the research about principles of improvement science, including the strategies and tools for applying improvement science, such as the role that “networked improvement communities” (Bryk, Gomez, & Grunow, 2010) play in the process of improvement. Equally important is to develop knowledge of and the capacity to use the processes and tools for using evidence and data in a continuous cycle of inquiry and improvement, including how to analyze and interpret data on student-learning, demographics, and other data (Love, Stiles, Mundry, & DiRanna, 2008). Engaging in cycles of inquiry also requires that leaders know the models for creating a culture of data use and continuous improvement and how to apply the practices and strategies for supporting educators to use data and evidence, look for patterns and root causes, and monitor implementation initiatives over time to inform improvement (Forman, Stosich, & Bocala, 2017).

"We collect data whenever we work with anyone and we embed an 'after-action data collection process' in the action plans. The regional science leaders record every time they go out and do something in the schools, and they complete a branching survey with specific questions and intended outcomes. The data they collected are used to help us learn more about the impact of our work and how it meets the teachers' needs."

— Regional Science Coordinator

## Leaders' Reflection Questions

- What is your current understanding of improvement science and the strategies for engaging in continuous improvement? How might you enhance your knowledge?
- What processes and tools do you currently use to engage in cycles of inquiry? How well do those processes and tools support you and others to gather the evidence needed to improve your initiatives?
- To what extent do you and other leaders have a culture that supports data use and continuous improvement? What changes might be required to further enhance people's mindsets toward improving?

"We also share the state's NGSS implementation plan with regional science leaders during our professional learning — it really clarifies what are we being asked to do, and we engage people in constant formative assessment. For example, at the end of professional learning, we ask the teachers to write a postcard to themselves with their goals and where they want to be in two to three months. Then, two to three months later, we mail the postcards back to them for reflection. We are always looping back to prior experiences."

— Regional Science Coordinator



# Domain 2: Critical Actions

Figure 1.2. Critical Actions



Leaders need to engage in numerous actions that are critical to the effectiveness of the implementation of the NGSS (Figure 1.2). The cycle of Plan-Do-Reflect-Revise (Langley et al., 2009) guides the process of creating, carrying out, and continuously improving a multiyear NGSS implementation plan. As leaders implement their plans, they gather and use data and evidence on the effectiveness of each of the actions and gauge the extent to which they are achieving their goals. Based on their results, leaders may determine that they need to further enhance their own knowledge and/or refine the critical actions that they are taking toward their goals.

*"As leaders guiding the implementation of the NGSS, it is imperative that we take action to build ownership and buy-in at the state level first and then build common and coherent messages for all other levels. We developed clear messages that included the interconnections among learning standards and how to leverage other content areas. The NGSS invited conversations about the connections to math, ELA, health, and physical education."*

*— State School Directors' Association Leader*

Leaders need to consider how each of the critical actions is relevant to the specific focus of their work. The relevance may vary based upon specific leadership roles within the system. For example, state-level leaders might build a vision for the NGSS by advocating with policymakers to develop their understanding of the importance of science literacy and how teaching in ways identified in the NGSS promotes equitable opportunities for all students to learn science. School administrators and teacher leaders may build a common vision with families and key stakeholders at a local level, such as industry leaders in the community, and engage them in supporting the school's implementation of the NGSS. Regional or district-level leaders might partner with science faculty from local institutions of higher education to co-facilitate professional learning experiences for preK–12 teachers, or might conduct presentations to the local school board and build awareness of the need to align policies (such as local standards and curriculum adoption) with the NGSS.

*"Compared to leading implementation of the earlier standards, the world has changed, including the unprecedented level of systemic change. Much more is changing now. It takes tremendous thought and collaboration to advance the work. With the level and speed of the work, how do you prioritize the right things? We — district principals, district administrators, teacher leaders, and coaches — are studying and discussing how leaders have to toggle to get whole-system change right and how it applies to us: focusing direction, cultivating collaborative cultures, securing accountability, and deepening learning."*

*— Elementary School District Superintendent*

What follows is a description of the actions that are critical to the effectiveness of implementing the NGSS. Following the description of each critical action, we provide relevant reflection questions for leaders to consider.

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## Aligning Policies

As leaders begin planning, they need to consider the policies that will influence the effective implementation of the NGSS. For example, the sequencing of and requirements for the number and type of science courses that students take in middle and high school, as well as the required instructional time for science in elementary schools, directly influence how the NGSS are translated into the overall science curriculum. NGSS implementation also has implications for policies regarding adoption processes for the science curriculum and instructional materials, and implications for statewide assessment and testing guidelines and practices. Leaders may need to examine and refine the course sequences and requirements and adjust policies so that they are more aligned to the NGSS learning progressions. Other policies, such as time allocated for teachers' professional learning and the criteria for evaluation of teacher performance, also need to align with the shifts in practice called for in the NGSS. As leaders implement their plans, they need to continue assessing and refining their policies, especially as the state or local contexts change as implementation of the NGSS becomes more widespread.

*"It's getting our legislature thinking about innovative ways to make high school forward-thinking, and knowing that the high school state test is not the highest leverage factor — there are other levers, such as course credit hours, electives, and assessment requirements — the whole system of accountability. How can we get legislators smarter about what it looks like when districts engage in K–12 STEM learning for all in all of their schools — how do districts do that, how do they fund it, how do they staff it based on certification requirements in an integrative way of teaching? Teacher preparation, certification, inservice, policy works — all of these come together to create the conditions that support NGSS implementation in the classroom."*

— *State School Directors' Association Leader*

### Leaders' Reflection Questions

- What are our current state and district policies regarding science instructional time, science course sequencing, and requirements? In what ways do the existing policies support the implementation of the NGSS? In what ways do they conflict with the learning progressions in the NGSS, and how can we change the policies?
- What are our state and district policies for selecting and adopting science instructional materials? What tools and processes do we currently use to evaluate science instructional materials? How might we need to change or refine the policies and practices to better support teachers' access to high-quality science instructional materials designed for the NGSS?
- What policies do we currently have in place to support teacher professional learning? How is teacher leadership developed at the state level? Regional level? Local level? What are the requirements for leaders' professional learning? Are these requirements similar across the state, region, or district? Given that teachers and leaders are challenged with making significant shifts in their practices, how might we develop alternative structures for professional learning?

- What is changing in our state and our districts that may influence our policies, and how can we adjust them accordingly?

“My continued role with the state’s NGSS-implementation initiative is to attend their functions annually and speak to the administrators and teachers. But my more important role is to stay on top of state policy decisions related to the NGSS to ensure they support the best statewide implementation of the NGSS and to recruit other connections that I have to support the NGSS policy and implementation. I continue to advocate for science. We need to use every policy lever available.”

— State Board of Education Member

## Allocating Funding

In conjunction with aligning policies, leaders need to examine the funding sources and allocation of those sources to ensure that they are sufficient to support the changes in policies that have been made. For example, currently there is a lack of coherent K–12 science instructional materials to support implementation of the NGSS. Consequently, many districts and schools are supporting teachers to develop or adapt instructional materials that are designed for the NGSS, and are supporting these efforts through new models for professional learning. In order to support this type of initiative, leaders may need to shift funding out of science curriculum adoption and into teacher professional learning. Leaders also need to identify their sources of funding and explore additional avenues, such as partnering with local businesses and industries. As leaders implement their plans, they need to continue to reflect on the ongoing, as well as new, sources of funding in order to reconsider any allocations of funding because of changes in the context, such as changes in the availability of instructional materials designed for the NGSS.

“I was just meeting with a regional curriculum council. They were discussing allocating funds for instructional materials. Our perspective is that this is premature, without NGSS professional development first. Some of the district administrators reconsidered their funding focus after this discussion. There is an unfortunate misconception on their part that materials are enough. The professional development is needed to create conditions for academic discourse. If that doesn’t happen, the NGSS doesn’t come alive with social connection between students. Some administrators want to see materials in the classes. This creates tension for some teachers. For three to five years, I think it will be this way.”

— Statewide Science Initiative Director

## Leaders' Reflection Questions

- In what ways have we considered the implications for how to allocate funding, given the specific contextual needs in our districts and schools, such as the lack of K–12 instructional materials designed for the NGSS?
- What sources of funding have we relied on in the past? What are our federal, state, and local sources of funding, and how are these currently allocated? In what ways could we reallocate existing funds to support NGSS implementation? What opportunities exist for generating additional funds or pursuing grants?
- How can we position the implementation of science so that it is sustained in our state? In our districts?
- Which community partners are currently supporting our science programs and in what ways? How might we expand those partnerships to focus on supporting the implementation of the NGSS?

*"Career technical education [CTE] has a different funding line than basic education, so if I can cross CTE with science courses, we can bring in additional funding. I can fund teachers' time to participate in NGSS work through CTE money."*

*— District Science Coordinator*

## Assessing the System

Knowing the current status of science teaching and learning and the six system drivers will be an important step for leaders to take as they begin planning for the implementation of the NGSS. Examining the existing contexts provides leaders with the knowledge and information they need to identify what needs to change in the system and where they are in relation to making the changes in practices that are called for in the NGSS. Leaders will need to identify sources of data and other evidence to inform their understanding of the current status and use this information to guide their actions. For example, they can look for available data about the success of prior standards implementation and see if those data raise any issues that need to be addressed or shed light on what has worked in the past. Data on the history of past change efforts can help assess the extent to which the system is organized to lead a change effort like the NGSS. Likewise, it may be important to gather data about how science is currently being taught to discover if there are schools or individual teachers who are already moving NGSS instructional practices forward. Leaders will also need to assess the extent to which their own existing knowledge base supports them to lead the implementation of the NGSS and whether there are gaps that they may need to address. Over time, contexts will change, and leaders need to stay attuned to these changes so that they can adjust their plans and the actions that they are taking.

"We wanted to do more than we had when we adopted the Common Core. The context was there to leverage the national energy toward the NGSS — the science education community was nationally organized — and we wanted to identify how to bring them in and honor their work, but also to have them learn about all of our school districts and how to support them. We wanted to build on existing partnerships who already understood our statewide professional learning networks. We also wanted to look carefully at how to build on prior work in leveraging leaders — regional coaches; state science coordinators; and teacher leaders in ELA, math, and science — and how to utilize the NGSS to create the opportunities to bring the three subjects together."

— *State School Directors' Association Leader*

## Leaders' Reflection Questions

- What data have we gathered (such as student learning data, projections for future employment in STEM, and data on educator quality) to inform our understanding of the current status of science teaching and learning? What additional data do we need, and how will we access those data?
- Given the changes in teaching practices called for in the NGSS, and the leadership required to guide and support those changes, do we, as leaders, have the requisite knowledge and understanding of the NGSS? What is the priority for our learning?
- What sequence of activities is needed to develop relationships and partnerships with key stakeholders?
- For our data analyses, what lessons can we build on from our prior standards initiatives? What challenges might we anticipate, and how can we address them?

"One of the things I did when I came in last year was to identify ways our system might need to change to support the transition to the NGSS. I reorganized the staff, and we now have NGSS specialists for elementary and for secondary who facilitate professional development with teachers at those levels. We all stay abreast of and connected to the district, our regional centers, and state-level activities. We are connected to statewide work and not just what is happening in our own district."

— *District Science Coordinator*

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## Building a Shared Vision

As leaders begin working with others toward the implementation of the NGSS, it is important to build a shared vision that is based on research and data about the importance of successful implementation of the NGSS. A vision that is embraced by others is developed collaboratively with key stakeholders, including families, students, and leaders at all levels of the system. It identifies goals for student learning and teaching, articulates how the NGSS aligns with and supports other content areas, and includes indicators of success. Building a shared vision is not a trivial task. Leaders need to carefully scaffold opportunities for dialogue and knowledge-building to support a sustained vision that is firmly held by a growing number of educators. Throughout the implementation process, leaders need to attend to how well they are moving toward the vision and may need to adjust the implementation of critical actions.

*"Building a vision among all stakeholders was critical. We needed to build that vision with private industry, advocacy groups, regional education centers, state leaders throughout the department of education, and everyone in the communities. Our focus was on the NGSS being a substantial change — in practice and in relationships — but a change that, with patience, we could achieve. Because our state-wide implementation plan built on frameworks and structures that involved people who did not often interact, we had to build relationships. In fact, they were all vying for their own content areas and were not very collaborative. Our NGSS work changed the culture — we created the conditions to build those relationships, and we developed a new vision of collaboration."*

— State Department of Education Leader

### Leaders' Reflection Questions

- As a leader, what is my vision of NGSS teaching and learning? How do my beliefs and knowledge inform that vision? What are my perceptions of my colleagues' vision? How similar or different are those visions?
- What specific steps do we need to take to provide opportunities for a wide range of leaders and key stakeholders to engage in building a shared vision?
- How are we supporting other leaders to build a shared vision with their colleagues and those that they lead and support?
- How might our shared vision of the NGSS link with visions of other state or local reform efforts or initiatives?

*"I learned about the conceptual shifts in the NGSS: the DCIs, CCCs, and the eight practices. With practices such as argumentation and modeling, the NGSS are an updated way of thinking about how scientists work and how scientists interact with engineers to solve human problems. By the end of that three-hour session, I was convinced that the NGSS were the way to go. I continue to advocate for science."*

— State Board of Education Member

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## Designing and Implementing Professional Learning for Teachers and Leaders

Sustained, effective professional learning for teachers and leaders is an essential component for ensuring the implementation of the NGSS. Given the complexity of the innovations in the NGSS, it is more important now than in the past to focus teachers' learning within the context of their own classrooms. New and unique models for teacher professional learning are emerging that embed teachers' learning of the NGSS into opportunities to practice teaching NGSS-based lessons. To design professional learning experiences that align with teachers' and students' learning needs, leaders need to develop and apply their knowledge of these emergent models.

*"We have several professional networks and alliances in our state, and every principal is a member of the school principal association network. We co-led and co-facilitated summer retreats with principals, hosted at our lab. Principals were introduced to science and we built awareness of the NGSS. Then, during the academic year, principals and their teachers came together to engage in examples of immersion and read research. In one session for principals, I taught an NGSS lesson and the principals discussed how they would evaluate the lesson — what they would observe, how to evaluate the teacher moves and the student engagement, how they would know if NGSS was happening, and how they would assess if the lesson aligned with the teacher's formative assessment in the lesson. It was very powerful. Elementary principals often do not want to observe teachers teaching science lessons, but this experience really got them more on board. The principals got together and created a short video clip about why they 'care about science' and posted it on the network's website — one of the vehicles for communication with the public. We've now done this five years in a row, and have seen principals continue to grow over time."*

*— National Laboratory STEM Education Director*

Science education leaders also need to have opportunities to deepen their knowledge of the NGSS and support changes in their leadership practices to guide the implementation of the NGSS. Similar to professional learning for teachers, leaders' professional learning needs to be situated in the actual context of leaders' work and needs to focus on the content of their work — leading the implementation of the NGSS. Leaders will need to be provided with the types of opportunities that they are expected to provide teachers. Their own knowledge and capacity-building experiences need to mirror the experiences, knowledge base, mindset, and skillset that they are expecting teachers to provide for students.

Designing, implementing, and supporting professional learning for teachers and administrators requires that leaders take an active role in establishing the systems that enable that learning to occur. Beyond ensuring that districts and schools are supported to engage in these new approaches to professional learning, it is equally important that the quality and design of the professional learning experiences themselves reflect what is known about high-quality professional learning. Leaders need to start the design and implementation of professional learning for teachers and other

stakeholders early in the planning process and include specific strategies for gathering data and feedback on the effectiveness and the impact of the professional learning in order to revise the design throughout the process of implementing the NGSS.

## Leaders' Reflection Questions

- In what ways does your current professional learning system reflect what is known about effective strategies for adult learning and the principles of effective professional learning? What is missing and might need to be enhanced in your designs for NGSS professional learning?
- What data will you need to gather to inform your understanding of the current needs of leaders, teachers, and students with regard to the NGSS? What data will you gather over time to inform changes in learning and practice and to inform revisions in the overall professional learning designs?
- What specific strategies will you use to support professional learning facilitators, including teacher leaders, to develop the necessary skills and knowledge (such as facilitation skills and knowledge of adult learning)?
- If your role as a leader does not include responsibility for designing or implementing professional learning, how will you ensure that this role is carried out?
- How will you align policies and funding to support professional learning?

*"In terms of teachers, pulling in key players as early adopters has worked well in our district. We purposefully pull in teacher leaders before working with the principals. We want the teacher leaders to work alongside teachers. Our goal is to build teacher leaders early in the process. I support NGSS implementation in many ways, including in-classroom instructional coaching, designing and facilitating professional development, supporting the on-site coaches with all content, working with the administrators, teacher leaders, department chairs, and curriculum revision team. From outside the K–12 system, we have a partnership with local colleges and universities and their graduate students to go into classrooms to work with teachers. I have met with the professors to help inform them of our NGSS implementation and to discuss the classroom impacts of the NGSS. My role is to help build capacity."*

*— District STEM Coach*

## Developing Communication Strategies

As leaders begin planning for NGSS implementation, one of the critical actions that builds on leaders' shared vision, is developing the key messages for communicating about the NGSS implementation and the means of getting those messages to multiple audiences and stakeholders. Leaders need to ensure that their messages include a clear articulation of the goals and outcomes of implementing the NGSS and the rationale for why the new standards are important for student learning. Leaders should also

develop plans for communicating the timeline and implementation sequence to build awareness and support. Knowing who the audiences are and why the NGSS may be important to those audiences can guide leaders in crafting targeted messages for each audience. As leaders facilitate implementation, they should also have ways for gathering feedback on the effectiveness of their communication strategies. Lastly, it is often very helpful to create an “elevator speech” which succinctly (in 30 seconds or less) makes the case for the NGSS and the difference that effective implementation will make for students.

“As we moved into the NGSS, we provided professional development for school directors and school board members and we had to think about their roles and how to message to them. What they needed was different than what we did with teachers. We focused on the shifts in the NGSS and created a narrative based on the shifts for people in different roles — from students to board members. We challenged teams to talk about the shifts. We also recognized that many of the audiences don’t speak ‘science talk,’ so we focused their messages on supporting innovation and 21st century skills, and why the NGSS are different from prior standards. We spent a lot of time talking about the NGSS in relationship to math and ELA and the way content is meant to be realized in the classroom. So, our message for science teachers was really an invitation to apply the NGSS in their classrooms. For school directors, it has been intriguing since they are responsible for money, they hire superintendents who hire staff, and our challenge was how to balance the relationships between school directors, district directors, and the school board members. We had to take all of those roles and relationships into account. The board approves or adopts the budget and the instructional materials. How to help them understand the importance of the NGSS?”

— *State School Directors’ Association Leader*

## Leaders’ Reflection Questions

- What are the key audiences that we need to communicate with to build their support and involvement? Why would each audience be interested in the NGSS, and why might the NGSS be important to them?
- What are our goals for communicating with each audience? What are the specific messages for each audience?
- How will we communicate with each audience? Which communication avenues will we use (e.g., social media, email and listservs, open houses, presentations, infomercials, public media)?
- How will we gather ongoing feedback and refine our communication, both the messages and the avenues for communicating?

"I see the big challenge as getting out to a big audience, including the non-science audience. The amount of time spent on explaining standards has been quite phenomenal. Compared to our previous science education standards where we just put them out there, we now have an NGSS concerted campaign and funding to do professional learning around the NGSS."

— State Department of Education Leader

## Engaging Families and Key Stakeholders

Families and other stakeholders are key audiences to communicate with and share the importance of the NGSS. Engaging families and key stakeholders means doing more than merely holding a discussion about the NGSS. Families have an invested interest in understanding what the new standards are and how the standards impact their children's learning and preparation for the future. Leaders can effectively involve families by embracing families as partners and collaborators in their children's education. For example, leaders can consider involving families in leadership development seminars, inviting them to be members on committees to select instructional materials, or asking them to participate in the development of the NGSS implementation plan.

Equally important is to consider who the key stakeholders are that can play active roles in supporting and/or implementing the NGSS. For example, some of the relevant stakeholders might include politicians; community members and organizations; businesses and industry organizations; higher education institutions; informal science centers; national and professional organizations; PTAs and parent engagement groups; state and district school boards; the scientific community; teacher unions and associations; STEM organizations and networks; and school, principal, and administrator associations. Leaders need to identify which key stakeholders can contribute to the standards implementation efforts, clearly articulate the roles that they might play, and continue to be open to new partnerships with stakeholders as opportunities arise during the implementation.

"We have a wide range of stakeholders supporting science teaching and learning in our school. There's a county park across the street from school, and our students do field studies at the park, and the rangers come to our school. We work with the local gardening association too. We also have a partnership with the local chamber of commerce. Locally, gravel is mined here and we have students mixing up their own concrete, which transfers into our geology lessons. We have guest speakers on materials science that do hands-on science with our students. We also got a grant this year with a project in which students use science and engineering to think about problem-solving. Our previous county office science coordinator involved us in the high-tech fair. That's where scientists talked about their own pathway into their careers. We helped them learn to talk about their pathways with young children so that students could really see how they got there."

— Elementary School Principal

## Leaders' Reflection Questions

- How have we engaged families in their children's science education in the past? How might we expand on those efforts and generate new approaches? What changes in our practices will be required to take on new approaches?
- Which key stakeholders have been involved in our science education programs in the past? What roles might they now play in supporting the implementation of the NGSS?
- How can we build on existing, or develop new, partnerships, collaborations, or relationships among community members or other key stakeholders to build capacity for supporting the implementation of the NGSS?
- What strategies will we implement for gathering ongoing feedback and identifying emerging needs throughout the implementation process?

"There is strong STEM industry in our region and there is community buy-in and support for the NGSS. Well, we don't hear the term NGSS, but there is definitely support for the types of learning that NGSS describes. Our community is based in the STEM sectors, and we have to think about our employer base. I spend a lot of time with the economic alliance and workforce, as well as thinking about the entry-level courses in community colleges and universities — how we can prepare our students to fill high-demand career opportunities that call for science and engineering knowledge and authentic application of that knowledge."

— District Science Coordinator

## Focusing on Equity and Accessibility

Focusing on equity and accessibility is an imperative for all educators. Leaders need to ensure that all students have opportunities to engage with the science learning outlined by the NGSS and that the relevant resources, funding, policies, and practices are supportive of all students. The NGSS provide extensive guidance on the importance of equity and accessibility, as well as case studies that highlight the ways that teachers can engage non-dominant student groups in NGSS learning. Engaging all leaders, educators, and key stakeholders with these case studies as a catalyst for dialogue can be one strategy for raising awareness of NGSS-guided teaching and learning in support of all learners. Leaders also can ensure that teacher professional learning develops teachers' knowledge and capacity for reaching all students through instructional practices that engage each and every student. The lens of equity and access should focus leaders' implementation of all of the critical actions and should clarify the approaches that leaders take in all aspects of guiding the NGSS implementation.

"In the past, discussions about equity have been imposed on people — such as leaders simply telling others that the standards are for all students — rather than thinking more deeply about how the standards are inclusive and provide opportunities for authentic inclusion of all students. We've taken the vision of the framework writers and embedded equity into our conversations about implementing the NGSS. We often discuss that there is no reason teachers cannot, or should not, strive to exceed the standards, but teachers must ensure that all students achieve the performance expectations."

— State Department of Education Leader

## Leaders' Reflection Questions

- How do we, as leaders, currently think about equity and accessibility? How do we rely on our beliefs and perceptions to inform the actions we take? How might we expand our understanding of equity and accessibility and ensure that our expanded understanding plays a greater role in guiding our actions?
- How do we support other leaders and educators to develop their own understanding about equity and access? How frequently are equity and access the "content" that is embedded within professional learning for teachers and leaders? How does embedding equity and access in professional learning experiences change the conversation?
- What data (such as course enrollment, course offerings, student surveys) can we gather to assess our effectiveness in ensuring equitable access for all students' NGSS learning?

"In most of our elementary schools, there is very little time for science. There are levers at the system level we want to pull to impact change — levers at both the local level and also larger state policies. We're asking all leaders to think deeply about what it means to have opportunities to learn science, and are striving to influence policies and practices so that all students have more opportunities, across all of the grades."

— State School Directors' Association Leader

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## Forming Implementation Teams

At all levels of the system, leaders need to form implementation teams that are composed of members who have the authority and responsibility to enact an NGSS implementation plan, who represent the relevant areas of education (e.g., assessment, curriculum, professional learning), and have the leadership knowledge and understanding of the NGSS and the innovations in the NGSS to lead and implement the plan. Collaborative teams should include a wide range of members, including students, families, community members, and other key stakeholders. Collaborative teams of leaders who are guiding and driving the implementation of the NGSS are essential for providing collective leadership for the overall change process.

"I am on the state NGSS implementation team, and the group is composed of science education leaders from across the state who are representative of all sectors in the system. Our initial work was focused on understanding the NGSS and developing rubrics related to what constitutes NGSS awareness and what constitutes NGSS implementation. We developed a statewide plan with rollouts and a timeline and used tools and resources from one of our local universities that has been leading the NGSS nationally. We've carefully looked at our career technical education pathways and how CTE and NGSS align. We've learned about other initiatives throughout the state and have been able to incorporate those into our thinking and work to implement the NGSS."

— Higher Education Science Education Faculty

## Leaders' Reflection Questions

- Who are we considering to include on our implementation team? What existing knowledge and understanding of the NGSS does each person have, and how might we enhance any gaps in their knowledge?
- How are we ensuring that leaders at all levels of the system are supported to develop their own implementation teams?
- What strategies to address attrition are we building into our plans in order to ensure that new implementation team members have an opportunity to enhance their knowledge?
- How are we ensuring that the team reflects on its effectiveness and gathers feedback from anyone the team works with?

"Before the NGSS were even in development, we were intentionally working to build statewide leadership — steering committees and leadership teams — to guide our implementation of the Common Core standards. Having those teams in place set us up for statewide leadership for the NGSS. We built on the existing teams to add additional people from science content areas."

— State School Directors' Association Leader

"I am on the NGSS steering committee that includes principals and superintendents, and I represent the K–2 band, which is very under-represented everywhere I go. One of my roles is to be the voice for the youngest students in our educational system to ensure that they have the same opportunities to engage in NGSS learning that other students do at the higher grade levels."

— Elementary Teacher Leader

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## Selecting, Adopting, Developing, and Aligning Curriculum, Instructional Materials, and Assessments

The innovations in the NGSS necessarily require coherent curriculum guidelines along with instructional materials and assessments that are designed to incorporate the innovations into teachers' instructional practices and students' learning experiences. Achieving this goal is no small feat, as there currently is a lack of curricula, materials, and assessments that are designed for the NGSS. Local and national science educators are diligently striving to fill the existing gap. In the interim, many teachers are engaging in immersive professional learning to adapt or develop instructional materials and assessments for the NGSS. Leaders need to consider their current science education programs and instructional materials to determine the extent of changes needed and how to best approach those changes — whether to adapt or develop. In either case, educators will need tools and models for evaluating, selecting, adapting, or developing curriculum, materials, and assessments. Ensuring that teachers have access to instructional materials and assessments that support phenomena-driven, three-dimensional learning may require changes in policies regarding science textbook adoption processes, allocation of funding, and professional learning that is structured to immerse teachers in learning to use the materials. As the availability of materials increases, leaders will also need to anticipate how they will evaluate those materials and the materials' alignment to the curriculum guidelines.

“When I came into this position, the district was all set to have a grade 9–10 science adoption this year for the NGSS, but I pumped the brakes on that and convinced the district that we did not have the readiness or instructional materials to adopt. So, we have a development team to identify the NGSS instructional materials that we have in K–12 and develop a course map sequence. The team is also identifying the work that needs to be done in order to get the shifts we need and the time and funding resources we’ll need. We have representation across grades and regions — they meet regularly to unpack the standards and conceive of what could make sense, given the constraints for the course maps. A lot of work has been done to introduce the NGSS to secondary and elementary teachers and to some extent to the principals. What we’re focused on now is implementing NGSS as best we can with the instructional materials we have now. I made it really clear that we have to think of the transition to NGSS differently than in the past — it’s not just the *adoption* of instructional materials but also the *adaptation* of instructional materials.”

— District Science Coordinator

### Leaders' Reflection Questions

- How do our existing curricula and instructional materials support phenomena-driven, three-dimensional teaching and learning? What gaps need to be addressed? Which approach — revising or developing the materials — would best support our teachers?

- › What tools, processes, and models for evaluating, selecting, adapting, and developing curricula and instructional materials are we aware of? What more might we need to learn, and how will we access the information to increase our awareness?
- › To what extent do the changes in curricula and instructional materials impact our statewide science assessments? What specific steps will we take to ensure a cohesive assessment system from the classroom to the state assessment?

“This year, we’ve been working with middle and high school teachers and principals, teacher leaders, and our informal science education partner leaders. We’re studying the innovations in the NGSS and our task is to recommend what our secondary courses and course pathways would be to guide the redesign of courses, based on the NGSS. Our NGSS assessment system is moving to an 11th grade comprehensive science assessment, and that is the driver for redesigning the courses so that there is more equitable access for all students for three-dimensional learning.”

— District Science Coordinator

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## Using Data and Research to Monitor and Improve

Engaging in continuous improvement requires leaders to develop plans for gathering data at key points in the implementation of the NGSS, developing the capacity to analyze and make meaning of the data, and use the findings to refine the implementation plan and the critical actions that they are taking. Applying their knowledge of the change process, leaders can more accurately anticipate when they might expect to see changes in practice and can design their data collection plans to obtain the data that they will need. Leaders will need to gather a range of different types of data that can help them understand the quality and effectiveness of their work, the impact it is having on the intended people and practices, and how well the implementation efforts are moving people toward sustained implementation of the NGSS. Based on what leaders learn, they will need to continuously refine and revise their approaches and turn to the research on best practices to possibly expand their repertoire of strategies.

“Leaders need to collect data that shows how teachers are progressing with classroom implementation. The challenge with translating the NGSS into practice that I see that exists now includes teachers needing to have the knowledge, skills, and abilities for three-dimensional teaching, especially preservice teachers. We need to meet people where they are in their level of comfort with change, and that level varies from person to person. We need to gather data to know where people are.”

— State Science Teacher Professional Organization Leader

## Leaders' Reflection Questions

- What data do we currently gather to inform us about the effectiveness, quality, and impact of our science education initiatives? How do we use the findings to improve our initiatives? What gaps exist in data collection and/or use of the data? How can we enhance our overall data-collection and data-use processes to more effectively engage in continuously improving our implementation of the NGSS?
- What knowledge, skills, and tools do we currently have for engaging in continuous inquiry into data? What might we need to learn to enhance our capacity?
- How are we building others' capacity to engage in continuous inquiry into data and to use the results for improving their efforts to implement the NGSS?
- What is our current understanding of the research on best practices for implementing each of the critical actions? What, if anything, do we need to learn more about?

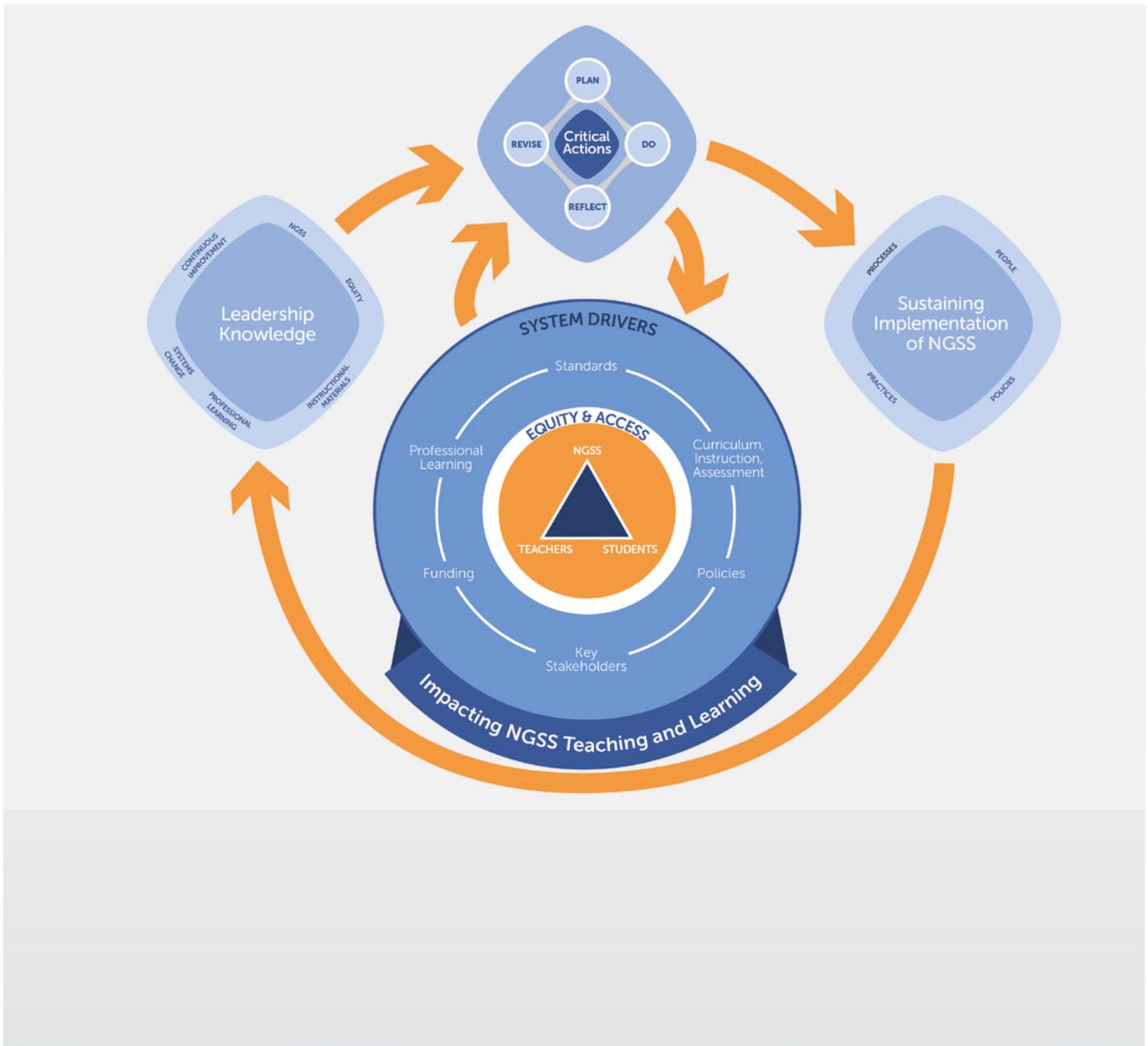
*"Leaders need to work with teachers to know where they are — such as whether they know the instructional shifts or whether they can read a performance expectation — in order to build on what they already know."*

*— County STEM Education Leader*



# Domain 3: Impacting NGSS Teaching and Learning

Figure 1.3. Impacting NGSS Teaching and Learning



Domain 3 focuses on impacting teaching and learning as the target of leaders' efforts to implement the Next Generation Science Standards. Central to this domain is the vision of NGSS learning in all classrooms for all students through the interactions between and among the NGSS, teachers, and their students (Figure 1.3). The NGSS are the drivers of what students learn and how instruction occurs. Surrounding this central vision of learning are six system drivers: standards; curriculum, instruction, and assessment; policies; key stakeholders; funding; and professional learning. Together these drivers exert a strong influence on teaching and learning in the classroom by defining what is taught, how it is taught, how prepared teachers are to teach, and the supports and policies that are requisite to ensuring successful implementation of NGSS teaching and learning. The system drivers of Domain 3 mirror some of the critical actions of Domain 2 and are emphasized again here because they are essential to the central vision of NGSS in classrooms.

*"The most essential things for leaders to have are an understanding at a deep level of three-dimensional learning and an understanding of how change happens at both the systemic level and at the individual level for teachers. Leaders have to be connected with teachers and know the difference between vision and how to help teachers make the shifts towards that vision. If we're really leaders, we need a real working knowledge of how teachers implement the NGSS in their classrooms. We need to work with and listen to teachers who are implementing standards to see which teachers are making it work in their classes. For administrators, observational rounds are important. As leaders, we need to be really close to what happens in classrooms."*

*— Informal Science Education Institution Leader*

All leaders in the system need to consider the system drivers as they plan and implement the NGSS. Each leader's role within the system will inform the leader's particular means of focusing on the system drivers. For example, teacher leaders will focus on the standards for all content areas to inform their plans for how to support their colleagues in different disciplines to collaborate in designing ways to integrate the three dimensions of the NGSS into each discipline. State-level leaders will consider all of the content standards as they strategize how to best allocate funding and align policies in support of all disciplinary areas. School administrators will need to develop an understanding of the standards and the innovations in the NGSS that enable them to conduct observations and evaluations in science classrooms and to refine teacher evaluation guidelines.

What follows is a description of the system drivers that impact NGSS teaching and learning. Following the description of the system drivers, we provide relevant reflection questions for leaders to consider.

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## System Drivers

As leaders consider the six system drivers, they need to understand the NGSS and how state standards for other disciplines (such as English language arts, mathematics, engineering, technology, computer science, career and technical education, and 21st century learning) overlap with the NGSS. Using their knowledge of the standards, they create K–12 science curriculum guidelines and learning goals. By building standards into educator evaluation and professional learning expectations, leaders can create accountability that encourages teachers to use standards-based practices. Their designs for professional learning systems should adhere to standards for effective professional learning. Leaders need to provide ongoing, collegial, effective opportunities for educators to learn to use the standards, and need to ensure that professional learning focuses on supporting the vision — the NGSS, teachers' practice, and students' learning. For other system drivers, leaders need to put in place processes for selecting and/or developing coherent and aligned curriculum, instructional materials, instructional practices, and assessments. They need to consider ways to engage and partner with key stakeholders, including families, university partners, science museums, informal learning organizations, and business partners, to support NGSS implementation. They also need to align policies and allocate funding to support the implementation of the NGSS.

*"The toughest nut to crack is not having instructional materials to consider for adoption — and we really need high-quality materials to adopt. Think back to what was being developed in the 1990s and the strategies around implementation. There were national groups that really helped us to think systemically about a strategic plan that included materials. Now there is a huge gap — what is the 'what' we're supposed to implement? There is a huge expectation that school systems are supported to do this, and we can get people understanding and even ready to implement the NGSS, but there is no time and expertise for teachers or even others in the district to develop the materials. So, we are doing what we can to get this done! We can implement practices with the materials we have, we can use the CCC themes, but the performance expectations will not be addressed until we have instructional materials."*

— District Science Coordinator

*"College and career readiness is a great one to connect to the NGSS. We're looking at access into college and the requirements for undergraduates, and how our courses can align. In terms of career, we've set up science and engineering programs so we introduce career experiences and knowledge to get students on their career paths and encourage them to stay here in the community. 21st century skills — how many of our disciplines, other than science, really have those skills? I have to look at the NGSS and what we are trying to fit it into and how we make those adaptations. I have to look to where we get buy-in and where we can sell the story in the community. I just came from a district where a major science industry is located, and it's easy there! I can get them excited about the NGSS because of engineering and its connection to CTE."*

— District Science Coordinator

## Leaders' Reflection Questions

- What do you know about the current status of each of the system drivers? How might you leverage each system driver in support of NGSS teaching and learning?
- To what extent do the teachers and leaders you work with use standards to drive instruction and set learning goals in the classroom? What mechanisms are in place to use the NGSS to drive instructional decision-making, and how will you leverage these?
- To what extent do the teachers and leaders you work with use standards to select or develop curriculum and instructional materials? What processes are in place for the adaptation or development of instructional materials and assessments that are designed for the NGSS? How can you put these processes in place if they are not already established?
- What policies currently support teacher and student learning of the NGSS? Which ones may be in conflict with the ways that teachers and students should be engaging in the innovations of the NGSS? How will you leverage policies to better support NGSS-based teaching and learning?
- Which policies (state level or local level) can you impact most effectively? What assistance do you need in order to impact policies at more than one level?
- Which key stakeholders are currently involved in supporting science education? Which stakeholders are enlisted as partners to support NGSS teaching and learning? How can you leverage the involvement and engagement of a wide range of stakeholders to enhance NGSS implementation?
- What funding sources are currently allocated to support science education? How might you leverage additional sources to further support NGSS implementation? How might you reallocate funding to support specific aspects of your implementation plan, such as providing additional funding for teacher professional learning focused on developing instructional materials?
- What are the current designs for teacher and leader professional learning in science education? How might those designs be refined to focus on developing teachers' and leaders' knowledge and to support changes in their practices in relationship to the NGSS? How might teacher professional learning be leveraged to support the engagement of key stakeholders, developing curriculum guidelines, and/or developing instructional materials and assessments designed for the NGSS?

"We have a unique opportunity to be partners with the K–12 system's work on the NGSS through our organization. We're working on learning standards, accountability, and graduation requirements. I'm helping our internal committee learn about the many moving parts and what it means for each of their systems and what we want the legislature to do to support the conditions — not just the money — but also leveraging time and instructional materials, and to get the right people at the table."

— State School Directors' Association Leader

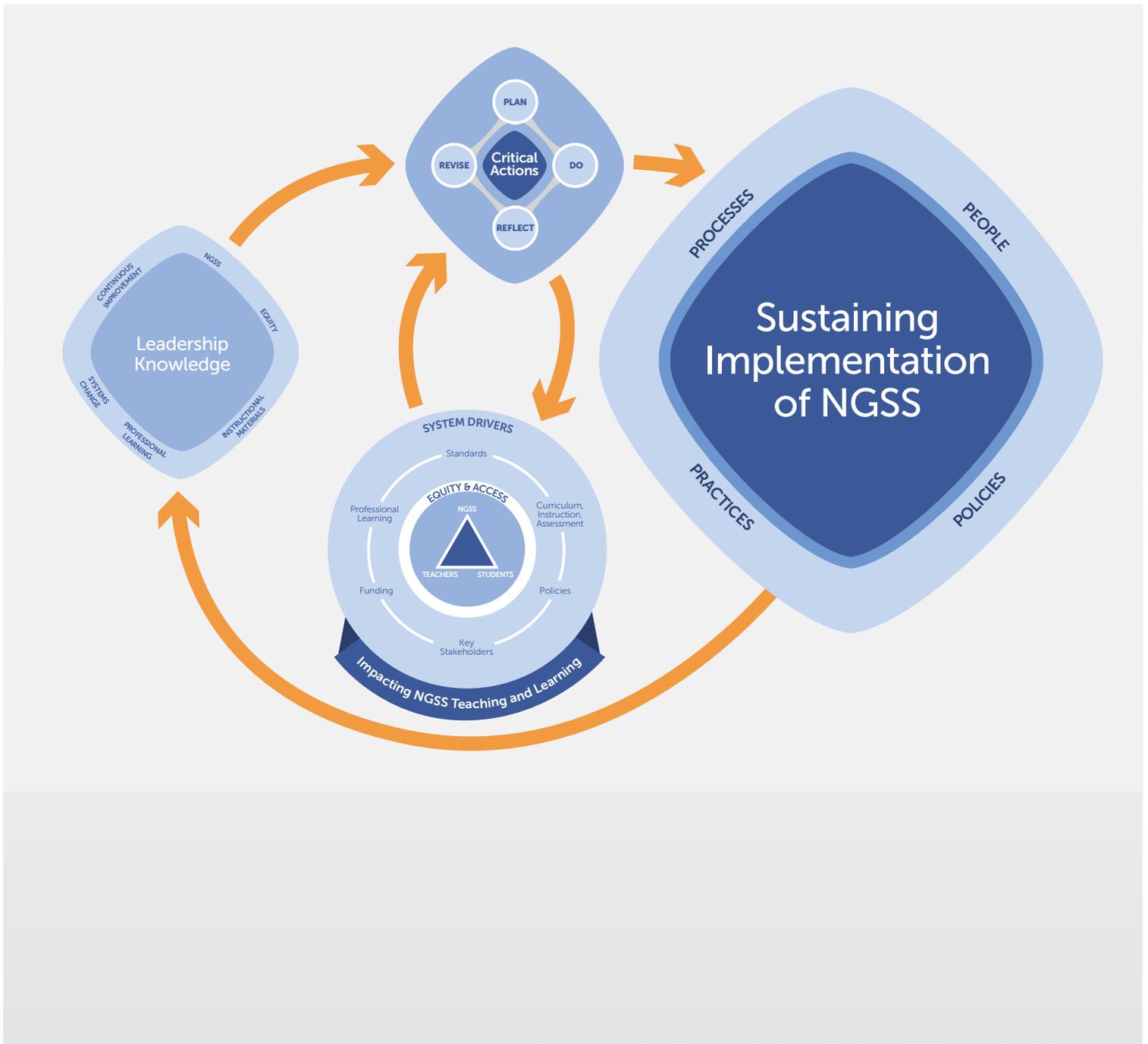
"It is essential for us as leaders to know that patience and persistence will be the key. There are so many systemic challenges that we face, and NGSS implementation is part of a broader shift in the education system. We need to learn how to draw connections between successful NGSS implementation and how it is supportive of the rest of our education system."

— *State Science Teacher Professional Organization Leader*



# Domain 4: Sustaining Implementation of NGSS

Figure 1.4. Sustaining Implementation of NGSS



Domain 4 represents the overall goal of leaders' work of sustaining the effective use of the NGSS in all education settings that they influence and support. Within this domain, leaders are continuously assessing whether they are achieving effective implementation of the NGSS and what they need to do next to deepen sustainable implementation (Fixen, Naoom, Blase, Friedman, & Wallace, 2005). They continually monitor progress and the results achieved thus far and they engage stakeholders in improving, deepening, and scaling up their use of the NGSS. Through this process, leaders continue to learn and grow and identify what, if anything, is needed to further enhance their knowledge, mindsets, and skillsets to ensure that the leaders are effective in Domains 1, 2, and 3.

*"My role isn't to 'figure it out,' but rather to put the pieces together and get barriers out of the way so the experts can do their work. My work is about how to help others do what they need to do. Our work is to help get barriers out of the way."*

*— County Educational Services Association Leader*

In this domain, leaders examine progress and results in four key areas that influence sustaining implementation of the NGSS: people, policies, processes, and practices (Figure 1.4) (Hall & Hord, 2015; Crandall & Loucks, 1983; Loucks & Zacchei, 1983). Each of these areas is described below, followed by relevant reflection questions for leaders to consider.

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## People

The Concerns-Based Adoption Model (Hall & Hord, 2015) reminds change leaders that change happens in individuals first and organizations second. When a considerable number of people in an organization make individual change, only then does organizational change happen and stick. To sustain the transformation inherent in the implementation of the NGSS, leaders keep this idea in the forefront of their work. They focus on people. Leaders consider how the people affected by the new science education standards have been involved in planning and leading the effort and seek to increase involvement, ownership, and leadership. They continue to enroll and involve beginning teachers in the process and keep track of which teachers have been involved in the work. They use data to assess where people are in the process of learning to implement the NGSS and circle back to key people who seem to have dropped out. They seek out and authentically listen to the concerns or problems that teachers, students, and other key people are encountering. Leaders pay attention to where people are in their use of the NGSS. They access and share data to celebrate positive results, identify any emerging challenges, and remove barriers to the use of the NGSS as quickly as possible. Leaders connect with people and foster collaborative problem-posing and problem-solving.

"To better inform our work with teacher leaders, we thought about what we expect to see in NGSS classrooms and what we expect to see teacher leaders doing to support classroom teachers, and what emerged from our thinking was a 'levels of use' document. We identified the key objectives for teacher leaders and the resources to support each key objective. Originally, this was my own thinking to guide my own work, but the state department of education really liked the structure and the results we gathered, so it has now been instituted as a measure of growth for all teacher leaders in all content areas. Our data — the way we measure our effectiveness as teacher leaders — is to look at the levels of use in teachers' classrooms that we work with. Teachers go through a self-analysis and do a pre/post reflection and rate themselves on their use of the NGSS. In the fall, teachers were in 'orientation' and shifted to 'mechanical' by the spring. That's huge! We also did a statewide CBAM [Concerns-Based Adoption Model] 'stages of concern' survey on the NGSS. Last year we did a baseline and will do it again this year. Our purpose is to really know and understand where people are so that we can target our professional development."

— Regional Science Coordinator

## Leaders' Reflection Questions

- How have we engaged a critical mass of people in this work? Who have we not yet engaged that we want to include? How do we help them come on board?
- What is the current understanding of those involved in the NGSS and what it means to implement the NGSS? What other support, if any, do they need to increase their use of the NGSS?
- What have we identified as powerful strategic events or leverage points to help teachers in their NGSS journey?
- What barriers to success are teachers, students, and others encountering? What ideas do teachers have for addressing these barriers?
- How are we leveraging influencers and stakeholders to bring more teachers, parents, and other stakeholders on board with the NGSS? How can we reach more educators? What are we doing as leaders to support other leaders?

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## Policies

Policies provide direction and guidance that inform actions in organizations. They often specify who is accountable for what. When new practices are introduced without clear statements of how the new practices are aligned with or will revise existing policy, there may be confusion about what staff should do and there may even be resistance to taking any action without some clear statement about the new policy or expectations.

To increase the likelihood that NGSS implementation will be sustained over time, leaders examine how policy is aligned to the practices, resources, and systems required for sustainable implementation of the NGSS. Some policies may be misaligned. For example, policies that may be misaligned with the goals for the NGSS can be those focused on professional learning (e.g., requiring all teachers to attend mandatory professional learning that does not address the teaching of their content, or limiting professional learning to a few teacher release days); curriculum selection (e.g., policies that require the use of particular instructional texts that are not consistent with the NGSS); and requirements about teachers' schedules that limit time for teachers to collaborate on new instructional practices.

In addition to shaping formal policies, school and district administrators also play a critical role in setting expectations for sustaining the use of the NGSS by what they say and do. Administrators support the scale-up of the NGSS when they make clear and public statements that science is a priority, when they help teachers to find the time in the school day to learn and practice using the NGSS, and when they notice which teachers are falling behind and they provide the support needed. They also communicate with families and students about the importance of science learning. The work of leaders is to monitor and support the clarity of the expectations for using the NGSS and ensure that policies support sustained use of the NGSS.

*"We continue to work with policy folks to help them to write good policies that support the NGSS and that are informed and coherent. Our statewide networks often invite legislators to attend events, and there have been some real success stories. We continue to focus on funding for education in general, and to tie the NGSS to college and career readiness and the priorities of our local businesses and industries."*

*— State Department of Education Leader*

### Leaders' Reflection Questions

- What policies are in place to support NGSS implementation? How can we better leverage these?
- What policies conflict with effective use of the NGSS and need to be revised?
- Who needs to be made aware of the need to revise policies?
- How are we communicating with others to advocate for science teaching and learning?

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## Processes

There are multiple, ongoing processes that need to be in place and working well to sustain the NGSS. Leaders need to establish processes for ensuring that curricula are aligned to the vision of the NGSS, such as district curriculum frameworks, instructional materials selection processes, and lesson planning. Leaders need to ensure that the processes for educator evaluation, such as classroom observations, use criteria aligned to NGSS teaching. Leaders provide guidance for the processes for professional learning, such as the annual planning and scheduling of professional learning, creating systems for accessing and attending professional learning, and establishing professional learning communities that can be leveraged to support learning and using the NGSS for all science teachers.

“Teacher leaders in K–12 and inservice teachers are on our radar screen. We collaborate with the state department of education on an induction for new teachers program, and our preservice undergraduate teachers are a part of that initiative. We are able to reach preservice and inservice teachers through the program and are extending it to reach more teachers through a federal grant to provide professional development on effective mentoring with inservice and preservice teachers’ partners. It’s a model for building a stronger core of school partners where we place our preservice candidates. It’s been a positive experience for our teachers, and the schools see our preservice teachers as an added value to their classrooms and their students. We’re now exploring how we can share that model with our partners and make that type of collaboration stronger in every region and to learn from them about what they are doing.”

— Higher Education Science Education Faculty

### Leaders’ Reflection Questions

- How do the processes related to teaching and learning in the school and district support the NGSS? Are any misaligned with the vision of the NGSS? If so, how might we better align them?
- Are teachers evaluated on instructional methods that are inconsistent with the NGSS? If so, how might we address this inconsistency?
- Are professional learning systems that support teachers to select, implement, refine, and continuously improve their use of new approaches to science teaching and learning aligned with (or differentiated for) a range of different teachers’ learning needs?
- How are new teachers inducted? Is the professional learning system designed to prepare new or reassigned teachers to NGSS teaching?
- How are data collected and used to reflect on the extent to which the school and district are progressing in the use of NGSS-aligned practices?

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## Practices

One of the major challenges to effective implementation and sustainability of new standards is a lack of clarity about the specific new instructional practices that will be adopted and used, and which of the current instructional practices will be abandoned. Selecting and implementing clearly defined and classroom-friendly practices is essential. Leaders can monitor and support implementation of the NGSS by clarifying and communicating the changes that are expected in instructional practice and by providing tools and mechanisms for teachers to use in implementing these practices in ways that best fit their classrooms. Leaders know the extent to which teachers understand NGSS practices, and can implement them; leaders also know where the gaps are and how to provide ongoing support to teachers to ensure implementation.

“One of the big things we have done is through our partnership through the statewide alliance work that is done at the regional level. There are so many school districts in our region that we cannot facilitate professional learning directly with the teachers, so we work more closely with the science coaches and have established networking forums. We have focused on implementation of the NGSS, bringing vertical teams together from across districts that include district science coaches, administrators, and teachers. We bring them together in the forums to engage with current research on the NGSS and time to work on developing their strategic plans. Every school district and school has their own improvement plans that provide framing for their NGSS work. We didn’t want to duplicate their efforts, so we provided guidance to help them think about the systemic buckets they need to attend to, and to use what they learn from the research, their conversations, and their own district contexts to further enhance their plans. It’s all focused on supporting leaders to support their teachers as they implement the NGSS in their classrooms.”

— *Foundation Program Officer*

### Leaders’ Reflection Questions

- Have we clearly defined the specific practices teachers are expected to use to implement the NGSS?
- Have we provided ongoing support, professional learning, and feedback on the use of the practices?
- How are we monitoring implementation so that teachers who need help implementing new practices can get coaching and support?
- How are we building a community of practice? How are we involving teachers to share concrete examples of what the NGSS looks like in action in their classrooms?
- What is the evidence that the use of new NGSS instructional materials and practices are enhancing learning for students?
- What enhancements are needed to deepen the use of NGSS practices and increase student learning?



# Conclusion

The *Framework for Leading Next Generation Science Standards Implementation* is grounded in research and enhanced by the knowledge and experience of science educators who are leading the NGSS in their states, regions, districts, schools, and classrooms. It offers leaders at all levels of the education system a tool to inform them of the knowledge they need and the actions necessary to implement the NGSS. The framework is not intended as a stand-alone document. Rather, it should be used with the standards documents themselves and with other resources that are highlighted in this framework document. The framework is meant to provide an image of what leaders need to know and do. It can inform a process for leading the actions required to support and sustain the vision of NGSS teaching and learning in classrooms.

The framework reflects how developing understanding of the six foundational knowledge areas substantially prepares leaders to drive the critical actions needed to launch, continuously improve, and ultimately sustain effective implementation of the standards. It identifies the drivers in the overall education system that leaders need to influence and align with the goal of supporting equity and access for all students to engage in standards-based learning. Through reflection on and immersion in the four domains of the framework, including the examples, quotes from leaders, reflection questions, and suggested resources, individual leaders and teams of leaders charged with implementation of the NGSS can identify where they need to focus their efforts as they plan for leading the NGSS and as they implement and improve their plans. Our goal for science educators' use of the *Framework for Leading Next Generation Science Standards Implementation* is to support them as they lead change and support the implementation of the Next Generation Science Standards.



# Resources to Support Leaders

This resource list is intended to provide leaders with a range of articles, books, documents, and websites to support them in building on their leadership knowledge and guiding their critical actions related to implementing the Next Generation Science Standards (NGSS). Many of the resources were suggested by our project design team and NGSS leadership experts who have used them in their own work leading and implementing the NGSS. We learned about other resources through web searches and interviews with science education leaders in California and Washington.

The resource list does not currently include the many websites that have been developed to support targeted state- and local-level NGSS implementation in the states that have adopted NGSS, although we are aware that many states and districts are developing their own resources for leaders, and we encourage you to check for such resources in your own state. We will continue to update this resource list as new resources are developed and as we engage with leaders from across the country with the *Framework for Leading Next Generation Science Standards Implementation*.

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**F R A M E W O R K**  
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Next Generation  
Science Standards  
Implementation

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