NGSS Innovations and Instructional Materials

What makes the NGSS new and different and what are the resulting implications for how instructional materials need to be new and different to be designed for the NGSS?

Excerpt from Primary Evaluation of Essential Criteria (PEEC) for Next Generation Science Standards Instructional Materials Design

Version 1.1—December 2017

This excerpt from PEEC 1.1 describes what these innovations are and their implications for instructional materials. The PEEC tool is designed to evaluate instructional materials programs for the degree to which these innovations are present.

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The NGSS Innovations and Instructional Materials

The NGSS Innovations are the five most significant ways the NGSS advance science teaching and learning, when compared to previous standards and typical instructional and curricular practice in American schools. They build on the conceptual shifts described in Appendix A of the NGSS using lessons learned by educators and researchers since implementation efforts began to bring clarity and focus to what is truly innovative in the NGSS.

As the key ways that the NGSS are new and different, these innovations also provide the intellectual framework PEEC uses to evaluate science instructional materials.

This section describes each of the five NGSS Innovations and provides insight on how these innovations should be expected to appear in instructional materials. Each innovation is described with the following components.

- A summary statement that distills the key idea of the innovation.
- A quote connecting each innovation to the research of the *Framework*.
- A detailed explanation of the innovation, often with links to portions of the NGSS.
- A description what this innovation looks like in instructional materials.
- A table providing concrete examples of the changes this innovation describes instructional materials.

Innovation 1: Making Sense of Phenomena and Designing Solutions to Problems

Summary	Making sense of phenomena or designing solutions to problems drives student learning.

From the *Framework*:

> *The learning experiences provided for students should engage them with fundamental questions about the world and how scientists have investigated and found answers to those questions.*

Though "making sense of phenomena and designing solutions to problems" is not one of the three dimensions of the standards and "phenomenon" or "problem" are not words often found within the performance expectations, a close look will reveal that the ability of students to make sense of phenomena and design solutions to problems is indeed a core feature of these standards. The easiest place to see this explicitly is to look at the foundation boxes connected to each performance expectation, or in Appendix F: Science and Engineering Practices and Appendix G:

Crosscutting Concepts. These appendices provide additional detail about learning expectations in these two dimensions of the standards across grade levels and frequently reference making sense of phenomena and/or designing solutions to problems.

Explaining phenomena and engineering design problems are not entirely new to science teaching and learning—laboratory experiments have been a hallmark of science instruction for decades, phenomena have frequently been used to "hook" students into learning, and engineering activities have often been used for engagement or enrichment—but the expectation that they are an organizing force for instruction is an innovation. By organizing instruction around phenomena, students are provided with a reason to learn (beyond acquiring information they are told they will later need) and shifts student focus from *learning about a topic* to *figuring out why or how something happens*. Additionally, the focus on relevant, engaging phenomena and design problems that students can access addresses diversity and equity considerations by providing opportunities for students to make connections with the content based on their own experiences and questions. This leads to deeper and more transferable knowledge and moves everyone closer to the vision of the *Framework*.

Implications for Science Instructional Materials

As with science instruction, phenomena and problems are not new to science instructional materials, but the shift to an expectation that student sense-making and problem-solving is driving instruction means that materials will need to shift as well. In instructional materials programs designed for the NGSS, this shift should be obvious in the organization and flow of learning in student materials and a clear focus of the teacher supports for instruction and monitoring student learning (see Table 1 for additional ways that making sense of phenomena and designing solutions to problems are different in the NGSS). This focus should be clear in even a quick scan through instructional materials designed for the NGSS and, after a closer look, it should be clearly central to student learning within lessons and units and coordinated over the whole program in a way that is coherent for both students and teachers.

For more resources on how making sense of phenomena and designing solutions to problems are important for teaching and learning designed for the NGSS, visit https://www.nextgenscience.org/resources/phenomena.

The following table provides examples of what instructional materials programs designed for this NGSS Innovation include "less" of and "more" of. This is not an exhaustive list, but is intended to call out key evidence that should be looked for in evaluating instructional materials. It should also be noted that "less" does not mean "never" and "more" does not mean "always."

Table 1: Innovation 1—Making Sense of Phenomena and Designing Solutions to Problems

Instructional materials programs designed for the NGSS include:

Less	**More**
Focus on delivering disciplinary core ideas to students, neatly organized by related content topics; making sense of phenomena and designing solutions to problems are used occasionally as engagement strategies, but are not a central part of student learning.	Engaging all students with phenomena and problems that are meaningful and relevant; that have intentional access points and supports for all students; and that can be explained or solved through the application of targeted grade-appropriate SEPs, CCCs, and DCIs as the central component of learning.
Making sense of phenomena and designing solutions to problems separated from learning (e.g., used only as an engagement tool to introduce the learning, only loosely connected to a disciplinary core idea, or used as an end of unit or enrichment activity).	Students using appropriate SEPs and CCCs (such as systems thinking and modeling) to make sense of phenomena and/or to design solutions to give a context and need for the ideas to be learned.
Instructions for students to "design solutions" as a step-by-step directions-following exercise.	Students learning aspects of how to design solutions while engaged in the design process.
Only talking or reading about phenomena or how other scientists and engineers engaged with phenomena and problems.	Students experiencing phenomena directly or through rich multimedia.
Leading students to just getting the "right" answer when making sense of phenomena.	Using student sense-making and solution-designing as a context for student learning and a window into student understanding of all three dimensions of the standards.

Innovation 2: Three-Dimensional Learning

Summary	Student engagement in making sense of phenomena and designing solutions to problems *requires* student performances that integrate grade-appropriate elements of the SEPs, CCCs, and DCIs in instruction and assessment.

From the *Framework*:

> *Instructional materials must provide a research-based, carefully designed sequence of learning experiences that develop students' understanding of the three dimensions and also deepen their insights in the ways people work to seek explanations about the world and improve the built world.*

That there are three dimensions in the NGSS—the science and engineering practices (SEPs), the disciplinary core ideas (DCIs), and crosscutting concepts (CCCs)—is their most recognizable feature. The innovation of these three dimensions, however, lies not just in their existence in the standards, but in *how* they exist in the standards. The NGSS are designed to make the two important parts of this innovation clear: 1) that the all three dimensions are equally important learning outcomes; and 2) that the *integration* of the three dimensions is key for student learning.

It might seem like the existence of the three dimensions is the innovation, but each has a predecessor in prior state standards and all three existed in many of those standards documents in one way or another. Prior to the NGSS, the primary focus of most state standards was on "science content" expected for students to know or understand. This "science content" was the precursor of *disciplinary core ideas*. Many state standards also included at least one standard that highlighted what students needed to know about how scientists do their work—the precursor to the *science and engineering practices*. Often called "inquiry," this was an important component of many state standards documents. The precursors to the *crosscutting concepts* were also included in state standards documents, but were often not in the standards themselves. They were derived from the "Unifying Concepts and Processes" of the National Science Education Standards (NRC 1996), the "Common Themes" of the *Benchmarks for Science Literacy* (AAAS 2009), "themes" in Science for All Americans (AAAS 1989), and "crosscutting ideas" in NSTA's Science Anchors Project (2010).

How this information was organized in prior standards, however, conveyed a difference in the relative importance of these three areas of student learning and these differences had a significant impact on instruction, instructional materials, and assessments in science classrooms. The "science content" portions took up the majority of the standards and because of the sheer breadth of detailed information, most instruction that targeted the standards focused on ways to disseminate this information to students. Though "inquiry" was highlighted in prior standards documents, it was typically a single standard while many more were devoted to science content. The crosscutting concepts predecessors were frequently addressed either in the front matter of the standards documents and/or were buried in standards that were viewed as supplemental to core learning.

The NGSS, on the other hand, include all three dimensions in performance expectations, intentionally signaling that *all three dimensions are equally important for student learning*. Students cannot fully demonstrate understanding of disciplinary core ideas without using the crosscutting concepts while engaging in the science and engineering practices. At the same time, they cannot learn or show competence in practices except in the context of specific content.

Building student proficiency in all three dimensions is a significant innovation all by itself, but the implication of this innovation goes beyond three separate strands of learning that are equally valued. The power of the three dimensions comes in their integration. The fact that these standards are written as three-dimensional performance expectations is significant and intentional, and should be reflected in student learning experiences. The *Framework* makes it clear that, “In order to achieve the vision embodied in the framework and to best support students’ learning, all three dimensions need to be integrated into the system of standards, curriculum, instruction, and assessment” (2012). Students develop and apply the skills and abilities described in the practices, as well as use the CCCs to make sense of phenomena and make connections between different DCIs in order to help gain a better understanding of the natural and designed world. The SEPs and CCCs provide multiple access points for students to approach learning goals, enabling different students in different contexts to access the same ideas. Simply parsing these dimensions back out into separate entities to be learned and assessed in isolation misses the vision of the NGSS and the *Framework*.

It is also important to clarify that the NGSS were designed to be *endpoints* for a grade level (K–5) or grade band (6–8; 9–12), and that they collectively describe what students should know and be able to do at that endpoint. The exact pairings of the dimensions in the PEs should not limit how the dimensions are integrated during classroom instruction and assessment. Because the very architecture of the NGSS models three-dimensionality, a PE might seem like a classroom lesson or unit, but it is **not** the intent of the NGSS to have students simply “do the PEs.” Since the PEs are written as grade-level endpoints, they often contain elements of the dimensions that may need to be taught at different times of the year. For example, a PE may include a DCI that fits early in a year of instruction, but also a more advanced level of a CCC or SEP that students might not be prepared for until the end of that same year. Furthermore, such an endeavor would be impractical and inefficient, as many PEs overlap with and connect to each other. Instead, three-dimensional learning experiences that integrate multiple SEPs, CCCs, and DCIs will be needed to help all students build the needed competencies toward the targeted performance expectations.

Implications for Instructional Materials

Instructional materials built for past science standards were organized just like the standards: inquiry or science process was frequently addressed in an opening chapter, a majority of the text was devoted to imparting “science content” to students, and the crosscutting concepts precursors were generally only implicitly included in materials with little to no emphasis in student learning goals. Instructional materials designed for the NGSS, on the other hand, must communicate the equal value of the three dimensions. This has implications for how student materials are organized and how the dimensions are presented in teacher support materials. This importance can and should be conveyed explicitly, but it is also conveyed by how the dimensions are presented. If one dimension is relegated to only appearing in the margins, appears with much less frequency, is not supported in teacher materials, or significant learning time is not devoted to ensuring student learning related to that dimension, then the materials fall short of what is expected by these standards.

Instructional materials designed for the NGSS will not only value all three dimensions of the standards, but will also integrate the three dimensions in instruction and assessment. For instruction, this means that student learning experiences must be anchored with three-dimensional student performances. It may not be possible for every student learning experience to be three-dimensional, but these 3D performances should be common and central to student learning. As mentioned above, the three dimensions of the standards should be integrated in ways that help students to make sense of the world around them and/or design solutions to problems—driving toward, but not limited by how the dimensions are integrated in the performance expectations. Instructional materials designed for this NGSS Innovation should make it clear which elements of the three dimensions are targeted by a given lesson or unit.

Instructional materials designed for the NGSS will integrate the three dimensions when monitoring student progress with embedded formative and summative assessments. As with instruction, this doesn't mean every assessment task or item, all the time, but it also means more than just an occasional three-dimensional assessment task here or there. The *focus* of measuring student learning should utilize items and tasks that are measuring the dimensions together—in pre-assessments, formative assessments, and summative assessments. Three-dimensional assessment tasks should be embedded throughout instructional experiences, taking advantage of the rich opportunities that are part of instruction during which students make their thinking visible to themselves, their peers, and educators.

Effective assessment of three-dimensional science learning requires more than a one-to-one mapping between the NGSS performance expectations and assessment tasks. It is important to note that more than one assessment task may be required to adequately assess students' mastery of some three-dimensional targets, and any given assessment task may assess aspects of more than one performance expectation. In addition, to assess both understanding of core knowledge and facility with a practice, assessments may need to probe students' use of a given practice in more than one disciplinary context. To adequately cover the three dimensions, assessment tasks will generally need to contain multiple components (e.g., a set of interrelated questions). Developers might focus on individual SEPs, DCIs, or CCCs in some components of an assessment task, but together, the components need to support inferences about students' three-dimensional science learning as described in a given set of three-dimensional learning targets.

For an introduction regarding assessments and the NGSS, see *Seeing Students Learn Science: Integrating Assessment and Instruction in the Classroom* (2017), the STEM Teaching Tool practice briefs on assessment, and Developing Assessments for the Next Generation Science Standards.

For some more concrete examples of what *Innovation 2: Three-Dimensional Learning* looks like in instructional materials programs, see Table 2. As was mentioned with Table 1, this is not an exhaustive list, but is intended to call out key evidence that should be sought in evaluating instructional materials. As a reminder, "less" does not mean "never" and "more" does not mean "always."

Table 2: NGSS Innovation 2—Three-Dimensional Learning

High-quality instructional materials programs designed for the NGSS include:

Less	**More**
Using science practices and crosscutting concepts only to serve the purpose of students acquiring more DCI information.	Careful design to build student proficiency in all three dimensions of the standards.
Teachers only posing questions that have one correct answer.	Teachers posing questions that elicit the range of student understanding. Students discussing open-ended questions that focus on the strength of evidence used to generate claims.
Administering additional assessments during instruction (e.g., vocabulary checks) that lack a clear feedback process to monitor and/or move student experiences to meet targeted learning goals.	Formative assessment processes embedded into instruction to capture changes in student thinking over time and adjust instruction
Assessments that focus on one dimension at a time and are mostly concerned with measuring students' ability to remember information.	Assessments within the instructional materials reflect each of the three distinct dimensions of science and their interconnectedness.

Less	More
Students learning the three dimensions in isolation from each other, i.e.: • A separate lesson or unit on science process/methods followed by a later lessons or units focused on delivering science knowledge. • Including crosscutting concepts only implicitly, or in sidebars with no attempt to build student proficiency in utilizing them. • Rote memorization of facts and terminology; providing discrete facts and concepts in science disciplines, with limited application of practice or the interconnected nature of the disciplines. • Prioritizing science vocabulary and definitions that are introduced before (or instead of) students develop a conceptual understanding.	Integrating the SEPs, CCCs, and DCIs in ways that instructionally make sense, as well as inform teachers about student progress toward the performance expectations, including: • Students actively engaged in scientific practices to develop an understanding of each of the three dimensions. • CCCs are included explicitly, and students learn to use them as tools to make sense of phenomena and make connections across disciplines. • Facts and terminology learned as needed while developing explanations and designing solutions supported by evidence-based arguments and reasoning.

Innovation 3: Building K–12 Progressions

Summary	Students' three-dimensional learning experiences are designed and coordinated over time to ensure students build understanding of *all three dimensions* of the standards, nature of science concepts, and engineering as expected by the standards.

From the *Framework*:

> *[Instructional materials] based on the framework and resulting standards should integrate the three dimensions—scientific and engineering practices, crosscutting concepts, and disciplinary core ideas—and follow the progressions*

articulated in this report… In addition, curriculum materials need to be developed as a multiyear sequence that helps students develop increasingly sophisticated ideas across grades K–12.

There are two components to this innovation. This first is what was described in the quote from the *Framework* above: coherently building all three dimensions from kindergarten through the twelfth grade. The second part of this focuses on how both engineering and the nature of science are embedded across all grade levels.

Building the Three Dimensions

While the three dimensions have appeared in past standards, the NGSS are the first standards to build all three dimensions over time. Past standards may have included limited progressions for both science and engineering practices (SEPs) and disciplinary core ideas (DCIs), but the NGSS progressions are more robust in several ways. The precursors to the crosscutting concepts (CCCs), on the other hand, were generally incorporated into the front matter of standards without any indication of how they might be treated over time. Not only are the three dimensions intentionally integrated into the performance expectations, but these progressions are supported with three appendices—Appendix E: Disciplinary Core Ideas, Appendix F: Science and Engineering Practices and Appendix G: Crosscutting Concepts—that add additional clarity to how these dimensions build over time. The appendices break the grade banded expectations for each DCI, SEP, and CCC into smaller *elements* for each to help educators focus on what is unique about that dimension at that grade.

The SEP progressions in the NGSS are different because the more is expected for student engagement in the practices over time. The SEPs specify what is often meant by “inquiry” and address the range of cognitive, social, and physical practices that science and engineering require in ways that were not included in past standards. This means there are more specific expectations at each grade level. Furthermore, past science standards generally just increased the complexity of inquiry standards by adding complexity to what is now one of the SEPs in the NGSS--*planning and carrying out an investigation*. The features that were added over time over time sometimes represent entire SEPs, which, in the NGSS, are built in developmentally appropriate ways starting in kindergarten. For example, in state standards prior to the NGSS, defending the results and conclusions of an investigation might not be mentioned in the standards documents until the high school level. In the NGSS, students are expected to start building the practice of *engaging in argument from evidence* in elementary school and that practice is scaffolded across grades so that high school students are expected to have many opportunities to engage in this practice before even reaching high school. In a similar fashion, all eight practices are developed from kindergarten through high school. The added specificity of the practices provides guidance for how each one builds over time.

The DCIs are more focused than the “science content” of past standards, so the progressions here look different as well. To be included in the *Framework* (and the NGSS), an idea had to: have broad importance across one or more science disciplines; be important for understanding more complex ideas and solving problems; relate to the interests and life experiences of students and the world they live in; and be teachable and learnable over multiple grades with increasing sophistication. The DCIs are driven less by information that we think that students *should* know by a particular grade and more by focusing on the fundamental understanding that will prepare them for their lives beyond high school. As a result, the DCIs have fewer disconnected bits of information and are more focused on building these core ideas.

As was mentioned above, the predecessors to the CCCs were usually included in the front matter of standards rather than in the standards themselves. Their addition to each of the three-dimensional performance expectations of the NGSS means that this dimension of the standards has an expected progression for the first time. The learning expectations of the CCCs are scaffolded across the K-12 standards to help students connect knowledge from the various disciplines into a coherent and scientifically-based view of the world.

Advancing the way that the DCIs and SEPs are built over time while establishing the first progression for the CCCs is a significant innovation of the NGSS.

Implications for Instructional Materials

Instructional materials designed for the NGSS provide sustained learning opportunities from kindergarten through high school for all students to engage in and develop a progressively deeper understanding of each of the three dimensions. Students require coherent, explicit learning progressions both within a grade level and across grade levels so they can continually build on and revise their knowledge and expand their understanding of each of the three dimensions. High-quality NGSS-designed instructional materials must clearly show how they include coherent progressions of learning experiences that support students in reaching proficiency on **all** parts (e.g., all elements of the SEPs, DCIs, and CCCs) of the NGSS by the end of each grade level and across grades. Guidance should also be provided for teachers to adjust instruction of all three dimensions to meet the needs of their students. In programs that extend beyond a single year, these progressions should be coordinated over the full breadth of the instructional materials program.

This means, for example, that the way materials expect students use each science and engineering practice at the beginning of the school year should be significantly different from how they are expected to use each practice by the end of the year. Students should have experiences across the year designed to *develop* specific, grade-appropriate elements of each practice and opportunities to apply these previously developed elements in new situations. There are a variety of ways this might happen—initially providing supports for a practice and then strategically removing them over time; focusing on deliberately developing a small number of elements of a practice in a coordinated fashion throughout the year; practicing already-developed elements of a practice when a different practice is foregrounded—but it should be apparent in student materials how the practice is being used differently and the plan for how the variety of student experiences builds to the full practice should be clearly explained in teacher materials.

In a similar way, the CCCs and DCIs should be coordinated over time so learning of all three dimensions is coherent from a student's perspective and guidance should be provided to teachers that explains how the organization of student learning experiences builds each dimension for students.

See NGSS Appendix E, Appendix F, and Appendix G for more information about the learning progressions for each dimension and how they build over time. For some more concrete examples of what *Innovation 3: Building K-12 Progressions* looks like in instructional materials programs, see Table 3. As was mentioned with earlier innovations, this is not an exhaustive list, but is intended to call out key evidence that should be looked for in evaluating instructional materials. As a reminder, "less" does not mean "never" and "more" does not mean "always."

Table 3: NGSS Innovation 3—Building K-12 Progressions: Building the Three Dimensions

High-quality instructional materials programs designed for the NGSS include:

Less	**More**
Building on students' prior learning only for the DCIs.	Building on students' prior learning in all three dimensions.
Little to no support for teachers to reveal students' prior learning.	Explicit support to teachers for identifying students' prior learning and accommodating different entry points, and describes how the learning sequence will build on the prior learning.
Assuming that students are starting from scratch in their understanding.	Explicit connections between students' foundational knowledge and practice from prior grade levels.
Students engaging in the SEPs only in service of learning the DCIs.	Students engaging in the SEPs in ways that not only integrate the other two dimensions, but also explicitly build student understanding and proficiency in the SEPs over time.

Less	More
CCCs marginalized to callout boxes, comments in the margins, or are implicit and conflated with the other dimensions and therefore do not progress over time.	Students learn the CCCs in ways that not only integrate the other two dimensions, but also explicitly build student understanding and proficiency in the CCCs over time.
Including teacher support that focuses only on the large grain size of each dimension rather than digging down to the element level (e.g. the SEP "Analyzing and Interpreting data" rather than the grade 3–5 element of the same practice "Analyze data to refine a problem statement or the design of a proposed object, tool, or process."	Including teacher support that clearly explains out how the elements of the practices are coherently mapped out over the course of the instructional materials program.

Embedding Engineering Design and the Nature of Science

The NGSS include engineering design and the nature of science as significant concepts, embedding them throughout the performance expectations. In many ways they are addressed within the progressions of the three dimensions of the three dimensions just described, but there are also specific aspects of each that are highlighted within the NGSS beyond what was included in the three dimensions. Similar to the three dimensions of the standards, engineering design and the nature of science have been included in past science standards, but the degree to which and the way they are incorporated into the NGSS is a distinct part of this innovation of the NGSS.

The NGSS represent a commitment to integrating engineering design into the structure of science education by raising engineering design to the same level as scientific inquiry when teaching science disciplines at all levels, from kindergarten to grade 12. To ensure that this happens coherently across students' K–12 learning experience, (1) all the SEPs have elements that are explicitly focused on engineering; (2) there are specific engineering design DCIs throughout the standards; and (3) the ideas from the Engineering, Technology, Science, and Society disciplinary core idea in the *Framework* are integrated into the crosscutting concepts in each grade band. (See Chapter 3 in the *Framework* for a detailed description of how the practices are used for both science and engineering. Box 3-2 briefly contrasts the role of each practice's manifestation in science with its counterpart in engineering.) These engineering concepts and practices are embedded throughout the NGSS in the performance expectations (PEs) that are marked with an asterisk. There are also grade-banded engineering design-specific standards in the NGSS to ensure that student learning about engineering design concepts is coherent and builds over time. More details about how engineering was embedded in the NGSS can be found in [Appendix I: Engineering Design in the NGSS] and [Appendix J: Science, Technology, Society, and the Environment].

A deeper awareness and understanding of the connections between science and engineering helps all students to be prepared for their lives beyond high school. In particular, the increased emphasis of engineering in the NGSS has potential to be inclusive of students who have traditionally been marginalized in the science classroom and do not see science as being relevant to their lives or future. By solving problems through engineering in local contexts (e.g., gardening, improving air quality, or cleaning water pollution in the community), students gain knowledge of science content, view science as relevant to their lives and future, and engage in science in socially relevant ways.

Like engineering, some aspects of the nature of science are integrated directly into the three dimensions of the standards—the integration of scientific and engineering practices, disciplinary core ideas, and crosscutting concepts provide practical experiences for students that set the stage for teaching and learning about the nature of science—but this part of the Building K-12 Progressions innovation also goes beyond just the integration of the three dimensions. In addition to learning experiences that model how science knowledge is acquired, the NGSS incorporate eight major themes about the nature of science into the performance expectations. Four of these themes extend the scientific and engineering practices and four themes extend the crosscutting concepts. Though the nature of science was often addressed somewhere within past standards documents, it has not been embedded in the standards over time the way that it is in the NGSS. These eight themes and exactly how they are built into the standards are explained in more detail in NGSS [Appendix H: Understanding the Scientific Enterprise: The Nature of Science in the Next Generation Science Standards].

Implications for Instructional Materials

Though engineering has stand-alone standards for each grade band, it is important for instructional materials not to isolate or separate engineering from science learning. Engineering was intentionally embedded in the standards to ensure that it was not separated out and taught as a separate unit or chapter. All three dimensions of the standards include learning that is relevant to engineering and instructional materials should embed this learning throughout the program and provide clear support for teachers to see how engineering is embedded throughout the program. Instructional materials designed for the NGSS should make sure that engineering is not an enrichment activity or engagement tool, but is incorporated meaningfully with science throughout student learning, and included as explicit and integrated learning targets.

Instructional materials designed for the NGSS should ensure that the eight nature of science themes identified in Appendix H are likewise explicitly embedded throughout student learning experiences and teacher supports, building learning progressions across grade bands.

For more examples of what Embedding Engineering Design and the Nature of Science looks like in instructional materials programs, see Table 4. As was mentioned with earlier innovations, this is not an exhaustive list, but is intended to call out key evidence that should be looked for in evaluating instructional materials. As a reminder, “less” does not mean “never” and “more” does not mean “always.”

Table 4: NGSS Innovation 3—Building K–12 Progressions: Embedding Engineering Design and the Nature of Science

High-quality instructional materials programs designed for the NGSS include:

Less	**More**
Presenting engineering design and the nature of science disconnected from other science learning (e.g., design projects that do not require science knowledge to complete successfully, or an intro unit on the nature of science).	Engaging all students in learning experiences that connect engineering design and the nature of science with the three dimensions of the NGSS; not separated from science DCIs.
Presenting engineering design and/or nature of science in a hit or miss fashion, i.e. they are made apparent to students, but there is no coherent effort to coordinate or improve student understanding or proficiency over time.	Both engineering design and nature of science are thoughtfully woven into the three-dimensional learning progressions so that students receive support to develop their understanding and proficiency.
Introducing students to ideas about engineering design or the nature of science, but not expecting students to retain or apply this information.	Measuring student learning in relation to engineering design and the nature of science across a system of assessments.
Teacher support that only explains the importance of the nature of science and engineering design without a plan for scaffolding student understanding and application.	Teacher support that explains how engineering design and the nature of science are coherently mapped out over the course of the instructional materials program.

Innovation 4: Alignment with English Language Arts and Mathematics

Summary	Students engage in learning experiences with explicit connections to and alignment with English language arts (ELA) and mathematics.

From the *Framework*:

> *…achieving coherence within the system is critical for ensuring an effective science education for all students. An important aspect of coherence is continuity across different subjects within a grade or grade band. By this we mean "sensible connections and coordination [among] the topics that students study in each subject within a grade and as they advance through the grades" [3, p. 298]. The underlying argument is that coherence across subject areas contributes to increased student learning because it provides opportunities for reinforcement and additional uses of practices in each area.*

The NGSS not only build coherence in science teaching and learning but also provide connections with mathematics and ELA that are made explicit on each standards page. This degree of connection across content areas is a significant innovation of the NGSS and, as is highlighted in Appendix L and Appendix M, the NGSS went to great lengths to ensure that the English language arts and mathematics expectations of students were grade-appropriate (as determined by the Common Core State Standards for English Language Arts in Science and Technical Subjects and Mathematics).

Such convergence across content areas strengthens science learning for all students, especially for students whose time for learning science may have been diminished by policies driven by an accountability system dominated by reading and mathematics. Across the three subject areas, students are expected to engage in argumentation from evidence; construct explanations; obtain, synthesize, evaluate, and communicate information; and build a knowledge base through content rich texts. Additionally, students learn the crosscutting concept of *Patterns* not only across science disciplines but also across other subject areas of language arts, mathematics, social studies, etc. Furthermore, the convergence of core ideas, practices, and crosscutting concepts across subject areas offers multiple entry points to build and deepen understanding for these students.

Implications for Instructional Materials

Instructional materials designed for the NGSS will highlight and support teachers in making connections between science, mathematics, and English language arts. Grade-appropriate and substantive overlapping of skills and knowledge helps provide all students equitable access to the learning standards for science, mathematics, and English language arts (e.g., see NGSS Appendix D Case Study 4: English Language Learners).

For examples of NGSS Innovation 4: Alignment with English language arts and Mathematics, see Table 5. As was mentioned with earlier innovations, this is not an exhaustive list, but is intended to call out key evidence that should be looked for in evaluating instructional materials. As a reminder, “less” does not mean “never” and “more” does not mean “always.”

Table 5: NGSS Innovation 4: Alignment with ELA and Mathematics

High-quality instructional materials programs designed for the NGSS include:

Less	**More**
Science learning is isolated from related learning in mathematics and English language arts.	Engaging all students in science learning experiences that explicitly and intentionally connect to mathematics and English language arts learning in meaningful, real-world, grade-appropriate, and substantive ways and that build broad and deep conceptual understanding in all three subject areas.

Innovation 5: All Standards, All Students

Summary	Science instructional materials support equitable access to science education for all students.

From the *Framework*:

> *Communities expect many things from their K-12 schools, among them the development of students’ disciplinary knowledge, upward social mobility, socialization into the local community and broader culture, and preparation for informed citizenship. Because schools face many constraints and persistent challenges in delivering this broad mandate for all students, one crucial role of a framework and its subject matter standards is to help ensure and evaluate educational equity.*

The NGSS describe science expectations built on progressions of the disciplinary core ideas (DCIs), the science and engineering practices (SEPs), and crosscutting concepts (CCCs) used together in meaningful ways that both establish high expectations while providing the structure to support students from diverse backgrounds in meeting them. This manifests directly in other innovations of the standards; however, the implications for supporting all students go deeper than those opportunities previously mentioned. As such, this innovation emphasizes those features of implementing the NGSS that directly support all students, and particularly those from traditionally underserved groups, in establishing and maintaining both achievement and agency in science. Whereas innovations 1-4 describe *what* is different in the NGSS, innovation 5 describes *how* the features of the NGSS can be used to support all learners with a focus on implications for instructional materials.

The NGSS pose a vision for science education that goes beyond asking students to know scientific information, or even applying scientific information via practices. To truly meet the vision of the NGSS, all students need to be given the opportunity to *become* scientists and engineers—scientific explainers and problem solvers—within the walls of their classrooms. An important part of helping all students reach achievement in science is ensuring that they both identify as scientists and engineers, and develop scientific agency—that is, they engage with science directly as doers and drivers of scientific endeavors, value the ideas they bring with them, have ownership over science and their learning, and participate in serious, engaging learning experiences that are meaningful to them culturally and socially.

For further information and examples of how to support a range of students, please see NGSS Appendix D and the accompanying case studies.

Implications for Instructional Materials

Instructional materials designed for the NGSS provide opportunities for all learners, and guidance to teachers for supporting diverse student groups, including students from economically disadvantaged backgrounds, students with special needs (e.g., visually impaired students, hearing impaired students), English learners, students from diverse racial and ethnic backgrounds, students with alternative education needs, and talented and gifted students. They do so using a variety of approaches, but also ensure the features of NGSS design are intentionally leveraged to support diverse learners as they develop proficiency, agency, and identity in science.

Specifically, instructional materials that are designed for the NGSS should:

1. Provide substantial opportunities for students to express and negotiate their ideas and prior knowledge, and capitalize on funds of knowledge (see NGSS Appendix D) as they are making sense of phenomena and designing solutions to problems.
2. Include diverse examples of scientists and engineers, including women and members other underserved populations, with whom a range of student groups can identify.
3. Offer meaningful opportunities for science learning experiences to value, respect, and connect to students' home, culture, and community.
4. Regularly provide opportunities for students to have ownership over their learning, as they explore and come to more deeply understand the core scientific ideas described by the standards.
5. Provide multiple access points, representations, and multimodal experiences for students to engage with the science at hand.
6. Provide multiple ways in which to make student thinking visible.

7. Provide teachers with ample tools and supports to help a wide range of students learn the designated content and skills, including through differentiation, engaging multiple scientific competencies, supporting scientific identities, and cultivating scientific agency.

For more examples of NGSS Innovation 5: All Standards, All Students, see Table 6. As was mentioned with earlier innovations, this is not an exhaustive list, but is intended to call out key evidence that should be looked for in evaluating instructional materials. As a reminder, “less” does not mean “never” and “more” does not mean “always.”

Table 6: NGSS Innovation 5: All Standards, All Students

High-quality instructional materials programs designed for the NGSS include the following:

Less	**More**
Materials including separate lessons or activities for students with different language or abilities as the only support for these learners.	Instructional materials create learning experiences that students with diverse needs and abilities can connect to and use to make progress toward common learning goals through a variety of student approaches within the same learning sequence.
Use of flashy phenomena as an interesting hook with the assumption that all students will find that compelling.	Inclusion of phenomena and problems that are relevant and authentic to a range of student backgrounds and interests, with supports for modifying the context to meet local needs and opportunities for students to make meaningful connections to the context based on their current understanding, personal experiences, and cultural background.

Less	More
Materials providing limited ways of meeting learning goals, such as reading about topics, listening to lectures and note-taking, and following written or oral labs.	Materials engaging the SEPs, CCCs, and DCIs as access points and diverse ways for students to learn (e.g., students using the practice of argumentation and evidence-based discourse to develop scientific understanding; students developing and using modeling to make sense of phenomena and problems as well as make thinking visible in ways that are less dependent on English language proficiency). Materials leverage the active components of the dimensions to provide students with ways to drive their own learning experiences, and identify and capitalize on opportunities for active learning.
Materials focus only on helping students learn and remember “the right answer.”	Materials help students learn the requisite information while also growing students’ ability to see themselves as scientists and engineers by providing students multiple opportunities to make their thinking visible, revisiting ideas, and engaging in scientific discourse with peers.
Teacher materials that focus on delivering information to students without providing support to help teachers value and build on the experiences and knowledge that students bring to the classroom	Teacher materials that include suggestions for how to connect instruction to the students' home, neighborhood, community and/or culture as appropriate, and provide opportunities for students to connect their explanation of a phenomenon and/or their design solution to a problem to questions from their own experience and meaningful components of their own contexts. Teacher materials provide suggestions for how to support students’ through multiple approaches to problems and phenomena.

Less	More
Teacher materials that only offer minimal or non-context specific support for differ-entiation.	Teaching materials that include: • Appropriate reading, writing, listening, and/or speaking alternatives (e.g., trans-lations, picture support, graphic organiz-ers, etc.) for students who are English learners, have special needs, or read well below the grade level. • Extra support (e.g., phenomena, repre-sentations, tasks) for students who are struggling to meet the targeted expecta-tions. • Extensions for students with high interest or who have already met the perfor-mance expectations to develop deeper understanding of the practices, discipli-nary core ideas, and crosscutting con-cepts. • Support for how to engage students in ownership of their learning.