Science

CURRICULUM FRAMEWORK

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RIDE Rhode Island Department of Education

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Section 1: Introduction

Background

The Rhode Island Department of Education (RIDE) is committed to ensuring all students have access to high-quality curriculum and instruction as essential components of a rigorous education that prepares every student for success in college and/or their career. Rhode Island's latest strategic plan outlines a set of priorities designed to achieve its mission and vision. Among these priorities is *Excellence in Learning*. In 2019 **Rhode Island General Law (RIGL) § 16-22-31** was passed by the state legislature, as part of [Title 16 Chapter 97 - The Rhode Island Board of Education Act], signaling the importance of *Excellence in Learning* via high-quality curriculum and instruction. RIGL § 16-22-31 requires the Commissioner of Elementary and Secondary Education and RIDE to develop statewide curriculum frameworks that support high-quality teaching and learning.

The science curriculum framework is specifically designed to address the criteria outlined in the legislation, which includes, but is not limited to, the following: providing sufficient detail to inform education processes such as selecting curriculum resources and designing assessments; encouraging real-world applications; being designed to avoid the perpetuation of gender, cultural, ethnic, or racial stereotypes; and presenting specific, pedagogical approaches and strategies to meet the academic and nonacademic needs of multilingual learners.[1]

The science framework was developed by an interdisciplinary team through an open and consultative process. This process incorporated feedback from a racially and ethnically diverse group of stakeholders that included the Rhode Island Literacy Advisory board, students, families, the general public, and community partners.

Vision for Student Success in Science

There is no doubt that science — and therefore, science education — is central to the lives of all Americans. Never before has our world been so complex and scientific literacy is critical to making sense of it all. Science is also at the heart of America's ability to continue innovating, leading, and creating jobs for the future. That's why all students, regardless of whether they pursue college or STEM careers, should have access to high-quality K–12 science education (NGSS.org., 2013).

The goal of the K–12 Framework is to provide all students with experiences in the science and engineering practices to gain knowledge and an appreciation of the natural world and be able to engage in public discussion on related topics; to foster critical consumers of scientific and technological information in the world they live in; prepare a foundation for pursuing STEM careers; and to continue to learn about science outside of school regardless of the career paths they choose (National Research Council, 2012).

RIDE creates conditions for every Rhode Island student to think critically and collaboratively, and act as a creative, self-motivated, culturally and globally competent learner. Rhode Island students are prepared to lead fulfilling and productive lives, succeed in academic and employment settings, and contribute meaningfully to society (RIDE Strategic Plan, 2021).

Through a collaborative, state-led process, K–12 science standards have been developed that are rich in both content and practice and arranged in a coherent manner across disciplines and grades

[1] The legislation uses the term *English learners*; however, RIDE had adopted the term *multilingual learners* (MLLs) to refer to the same group of students to reflect the agency's assets-based lens.

to provide all students an internationally benchmarked science education. The NGSS were released in 2013 and are being implemented in states and districts across the nation.

Purpose

The purpose of the science framework is to provide guidance to educators and families around the implementation of the standards, particularly as it relates to the design and use of curriculum materials, instruction, and assessment. The frameworks should streamline a vertical application of standards and assessment across the K–12 continuum within Tier 1 of a Multi-Tier System of Support (MTSS), increase opportunities for all students to meaningfully engage in grade-level work and tasks, and ultimately support educators and families in making decisions that prioritize the student experience. These uses of the curriculum frameworks align with the overarching commitment to ensuring all students have access to high-quality curriculum and instruction that prepares students to meet their postsecondary goals.

Success Criteria

This framework should support educators in accomplishing the following:

- ✓ Equitably and effectively support the learning of all students, including multilingual learners and differently-abled students.
- ✓ Support and reinforce the importance of culturally responsive and sustaining education practices.
- ✓ Prepare students to thrive and succeed in college and/or their careers.

Guiding Principles for Rhode Island's Frameworks

The following five guiding principles are the foundation for Rhode Island's Curriculum Frameworks. They are intended to frame the guidance within this document around the use and implementation of standards to drive curriculum, instruction, and assessment within an MTSS. These principles include the following:

1. Standards are the bedrock of an interrelated system involving high-quality curriculum, instruction, and assessment.
2. High-quality curriculum materials (HQCMs) align to the standards and, in doing so, must be accessible, culturally responsive and sustaining, supportive of multilingual learners, developmentally appropriate, and equitable, as well as leverage students' strengths as assets.
3. High-quality instruction provides equitable opportunities for all students to learn and reach proficiency with the knowledge and skills in grade-level standards by using engaging, data-driven, and evidence-based approaches and drawing on family and communities as resources.
4. To be valid and reliable, assessments must align to the standards and equitably provide students with opportunities to monitor learning and demonstrate proficiency.
5. All aspects of a standards-based educational system, including policies, practices, and resources, must work together to support all students, including multilingual learners and differently-abled students.

What is 'Curriculum'?

A common misconception about school curricula is the belief that a curriculum is primarily the collection of resources used to teach a specific course or subject. A high-quality curriculum is much more than this. RIDE has previously defined curriculum as a "standards-based sequence of planned experiences where students practice and achieve proficiency in content and applied learning skills. Curriculum is the central guide for all educators as to what is essential for teaching and learning, so that every student has access to rigorous academic experiences." Building off this definition, RIDE also identifies specific components that comprise a complete curriculum. These include the following:

- ***Goals***: Goals within a curriculum are the standards-based benchmarks or expectations for teaching and learning. Most often, goals are made explicit in the form of a scope and sequence of skills to be addressed. Goals must include the breadth and depth of what a student is expected to learn.
- ***Instructional Practices***: Instructional practices are the research- and evidence-based methods (i.e., decisions, approaches, procedures, and routines) that teachers use to engage all students in meaningful learning. These choices support the facilitation of learning experiences in order to promote a student's ability to understand and apply content and skills. Strategies are differentiated to meet student needs and interests, task demands, and learning environment. They are also adjusted based on ongoing review of student progress towards meeting the goals.
- ***Materials***: Materials are the tools and resources selected to implement methods and achieve the goals of the curriculum. They are intentionally chosen to support a student's learning, and the selection of resources should reflect student interest, cultural diversity, world perspectives, and address all types of diverse learners. To assist local education agencies (LEAs) with the selection process, RIDE has identified and approved a collection of HQCMs in mathematics and English language arts (ELA) in advance of the 2023 selection and adoption requirement for LEAs. The intent of this list is to provide LEAs with the ability to choose a high-quality curriculum that best fits the needs of its students, teachers, and community. Each LEA must choose a curriculum from the list for core mathematics, ELA, and science content areas per the timelines outlined in RIGL§ 16.22.30-33. When possible, LEAs should adopt early because every student in Rhode Island deserves access to HQCMs.
- ***Assessment***: Assessment in a curriculum is the ongoing process of gathering information about a student's learning. This includes a variety of ways to document what the student knows, understands, and can do with their knowledge and skills. Information from assessment is used to make decisions about instructional approaches, teaching materials, and academic supports needed to enhance opportunities for the student and to guide future instruction.

Another way to think about curriculum, and one supported by many experts, is that a well-established curriculum consists of three interconnected parts all tightly aligned to standards: the intended (or written) curriculum, the lived curriculum, and the learned curriculum (e.g., Kurz, Elliott, Wehby, & Smithson, 2010). Additionally, a cohesive curriculum should ensure that teaching and learning is equitable, culturally responsive and sustaining, and offers students multiple means through which to learn and demonstrate proficiency.

The *written curriculum* refers to what students are expected to learn as defined by standards, as well as the HQCMs used to support instruction and assessment. This aligns with the 'goals' and 'materials' components described above. Given this, programs and textbooks do not comprise a curriculum on their own, but rather are the resources that help to implement it. They also establish the foundation of students' learning experiences. The written curriculum should provide students with opportunities to engage in content that builds on their background experiences and cultural and linguistic identities while also exposing students to new experiences and cultural identities outside of their own.

The *lived curriculum* refers to how the written curriculum is delivered and assessed and includes *how* students experience it. In other words, the lived curriculum is defined by the quality of instructional practices that are applied when implementing the HQCMs. This aligns with the 'methods' section in RIDE's curriculum definition. The lived curriculum must promote instructional engagement by affirming and validating students' home culture and language, as well as provide opportunities for integrative and interdisciplinary learning. Content and tasks should be instructed through an equity lens, providing educators and students with the opportunity to confront complex equity issues and explore socio-political identities.

Finally, the *learned curriculum* refers to how much of and how well the intended curriculum is learned and how fully students meet the learning goals as defined by the standards. This is often defined by the validity and reliability of assessments, as well as by student achievement, their work, and performance on tasks. The learned curriculum should reflect a commitment to the expectation that all students can access and attain grade-level proficiency. Ultimately, the learned curriculum is an expression and extension of the written and lived curricula, and should promote critical consciousness in both educators and students, providing opportunities for educators and students to improve systems for teaching and learning in the school community.

Key Takeaways

- First, the **written curriculum** (goals and HQCMs) must be firmly grounded in the standards and include a robust set of HQCMs that all teachers know how to use to design and implement instruction and assessment for students.
- Second, the characteristics of a strong **lived curriculum** include consistent instructional practices and implementation strategies that take place across classrooms that are driven by standards, evidence-based practices, learning tasks for students that are rigorous and engaging, and a valid and reliable system of assessment.
- Finally, student learning and achievement are what ultimately define the overall strength of a **learned curriculum**, including how effectively students are able to meet the standards.

What is a Curriculum Framework?

All of Rhode Island's curriculum frameworks are designed to provide consistent guidance around how to use standards to support the selection and use of HQCMs, evidence-based instructional practices, as well as valid and reliable assessments — all in an integrated effort to equitably maximize learning for all students.

The curriculum frameworks include information about research-based, culturally responsive and sustaining, and equitable pedagogical approaches and strategies for use during implementation of HQCMs and assessments in order to scaffold, develop, and assess the skills, competencies, and knowledge called for by the state standards.

The structure of this framework also aligns with the five guiding principles referenced earlier. **Section 2** lists the standards and provides a range of resources to help educators understand and apply them. Section 2 also addresses how standards support selection and implementation of HQCMs. **Section 3** of this framework provides guidance and support around how to use the standards to support high-quality instruction. **Section 4** offers resources and support for using the standards to support assessment. Though Guiding Principle 5 does not have a dedicated section, it permeates the framework. Principle 5 speaks to the coherence of an educational system grounded in rigorous standards. As such, attention has been given in this framework to integrate stances and resources that are evidence-based, specific to the standards, support the needs of all learners — including multilingual learners and differently-abled students — and link to complementary RIDE policy, guidance, and initiatives. Principle 5 provides the vision of a coherent, high-quality educational system.

In sum, each curriculum framework, in partnership with HQCMs, informs decisions at the classroom, school, and district level about curriculum material use, instruction, and assessment in line with current standards and with a focus on facilitating equitable and culturally responsive and sustaining learning opportunities for all students. The curriculum frameworks can also be used to inform decisions about appropriate foci for professional learning, certification, and evaluation of active and aspiring teachers and administrators.

The primary audiences for the information and resources in the curriculum frameworks are educators in Rhode Island who make decisions and implement practices that impact students' opportunities for learning in line with standards. This means that the primary audience includes teachers, instructional leaders, and school and district administrators.

However, the curriculum frameworks also provide an overview for the general public, including families and community members, about what equitable standards-aligned curriculum, instruction, and assessment should look like for students in Rhode Island. They also serve as a useful reference for professional learning providers and higher education Educator Preparation Programs (EPPs) offering support for Rhode Island educators. Thus, this framework is also written to be easily accessed and understood by families and community members.

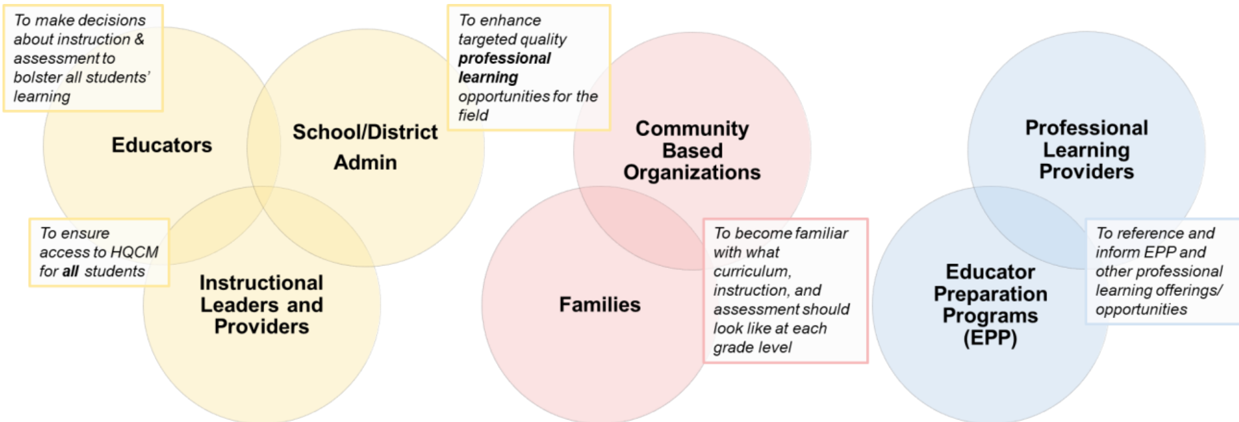
Summary of Section Structure

Section II: Implementing a High-Quality Curriculum	Section III: Implementing High-Quality Instruction	Section IV: High-Quality Learning Through Assessment
✓ The Practice Standards ✓ Content-Area Standards ✓ Connecting the Content and Practice Standards* ✓ Suggested Pathways/Progressions ✓ Professional Learning ✓ Selecting HQ Curriculum Materials*	✓ Principles of HQ Instruction ✓ HQ Cross-Content Instructional Practices ✓ Implementing HQ Lessons* ✓ Work-Based Learning* ✓ Professional Learning	✓ Principles of HQ Assessment ✓ Designing HQ Performance Assessments ✓ Designing HQ Rubrics ✓ Assessing Work-Based Learning ✓ Professional Learning

*Not applicable to all content areas

What does effective implementation of the Curriculum Framework look like?

Below are examples of how RIDE envisions the guidance and resources within this framework being used. These examples are not exhaustive by any measure and are intended to give educators an initial understanding of how to practically begin thinking about how to implement and use this framework to inform their daily practice.



Educators and instructional leaders such as curriculum coordinators, principals, and instructional coaches can use the curriculum frameworks as a go-to resource for understanding the HQCMs that have been adopted in their districts and to make decisions about instruction and assessment that bolster all students' learning opportunities. For example, the frameworks can be used to:

- Unpack and internalize grade-level standards and vertical alignment of the standards;
- Analyze HQCMs and assessment(s) adopted in the district and understand how the standards are applied within the instructional materials and assessment(s);
- Norm on high-quality instructional practices in each of the disciplines; and
- Guide decisions related to instruction and assessment given the grade-level expectations for students articulated in the standards and the high-quality instructional materials.

Educators, curriculum leaders, and instructional coaches can use the curriculum frameworks as a resource when ensuring access to high-quality instructional materials for all students that are culturally responsive and sustaining, and that equitably and effectively include supports for MLLs. For example, the frameworks can be used to:

- Unpack and internalize English language development standards for MLLs; and
- Plan universally designed instruction and aligned scaffolds that ensure all students can engage meaningfully with grade-level instruction.

District and school administrators can use the curriculum frameworks to calibrate their understanding of what high-quality curriculum, instruction, and assessment should look like within and across disciplines and use that understanding as a guide to:

- Make resources available to educators, families, and other stakeholders in support of student learning;
- Norm "what to look for" in classrooms as evidence that students are receiving a rigorous and engaging instructional experience; and
- Structure conversations with teachers and families about high-quality curriculum, instruction, and assessment.

District and school administrators, as well as EPPs and professional learning providers, can use the curriculum frameworks to enhance targeted quality professional learning opportunities for the field. For example, the frameworks can be used to:

- Enhance educator or aspiring educator knowledge about the standards and pedagogical approaches used in Rhode Island;
- Roll out a vision for curriculum and instruction in the district, followed by curriculum-specific professional learning;
- Build capacity of educators and aspiring educators to engage in meaningful intellectual preparation to support facilitation of strong lessons;
- Aid educators and aspiring educators in making sense of the structure, organization, and pedagogical approaches used in different curriculum materials; and
- Build capacity of educators and aspiring educators to address individual learning needs of students through curriculum-aligned scaffolds.

Families and community organizations can use the curriculum frameworks to become familiar with what curriculum, instruction, and assessment should look like at each grade level.

Overview and Connection to Other Frameworks

Each content area (mathematics, science and technology, ELA history and social studies, world languages, and the arts) has, or will soon, have its own curriculum framework. For educators who focus on one content area, all information and resources for that content area are contained in its single curriculum framework. For educators and families who are thinking about more than one content area, the different content-area curriculum frameworks will need to be referenced. However, it is important to note that coherence across the curriculum frameworks includes a common grounding in principles focused on connections to content standards and providing equitable and culturally responsive and sustaining learning opportunities through curriculum resources, instruction, and assessment. The curriculum frameworks also explicitly connect to RIDE's work in other areas including, but not limited to, MLLs, differently-abled students, early learning, college and career readiness, and culturally responsive and sustaining practices. Below is a brief overview of how this and the other curriculum frameworks are organized, as well as a summary of how the specific curriculum frameworks overlap and connect to each other.

Section	What is common across the content area curriculum frameworks?	What is content-specific in each content area's curriculum framework?
Section 1: Introduction	Section 1 provides an overview of the context, purpose, and expectations related to the curriculum framework.	Each curriculum framework articulates a unique **vision for how the framework can support high-quality teaching and learning.**

Section	What is common across the content area curriculum frameworks?	What is content-specific in each content area's curriculum framework?
Section 2: Implementing a High-Quality Curriculum	The introduction to this section defines how RIDE defines HQCMs in relation to standards. The final part of this section explains how HQCMs are selected in RI and provides related tools.	The middle section of each curriculum framework has **content-specific information about the standards behind curriculum resources and the vision for student success** in the targeted content area. The final part of this section includes some **specific information about the HQCMs for the targeted content area.**
Section 3: Implementing High-Quality Instruction	This section provides an overview of how high-quality instruction is guided by standards and introduces five cross-content instructional practices for high-quality instruction. This section also includes guidance and tools to support high-quality instruction and professional learning across content areas.	This section expands upon the cross-content instructional practices by providing **content-specific information about instructional practices.** This section also includes **more specific guidance and tools for considering instruction and professional learning in the targeted content area.**
Section 4: High-Quality Learning Through Assessment	The curriculum frameworks are all grounded in common information described here about the role of formative and summative assessment and how these align with standards. Some standard tools and guidance for assessment in any content area are also provided.	**Content-specific guidance about tools and resources for assessing students in the targeted content area** are included in this section.

Connections to Other RIDE Resources

This curriculum framework is designed to be a valuable resource for educators and families. It is intended to support classroom teachers and school leaders in developing a robust and effective system of teaching and learning. To achieve this, it also connects users to the vast array of guidance and resources that the RIDE has and will continue to develop. Thus, when logical, direct references are made, including direct hyperlinks, to any additional resources that will help educators, families, and community members implement this framework.

References

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Section 2: Implementing a High-Quality Curriculum

Introduction

Having access to high-quality curriculum materials (HQCMs) is an important component of increasing equitable access to a rigorous education that prepares every student for college and careers. In answer to this national movement to increase access through high-quality materials, the State of Rhode Island, in 2019, passed RIGL§ 16.22.30-33. The legislation requires that all Rhode Island Local Education Agencies (LEAs) adopt HQCMs in K–12 schools that are (1) aligned with academic standards, (2) aligned with the curriculum frameworks, and (3) aligned with the statewide standardized test(s), where applicable.

RIDE uses various factors to determine high quality, primarily using information from EdReports, a non-profit, independent organization that uses teams of trained teachers to conduct reviews of K–12 English language arts (ELA), mathematics, and science curricula. Informed by EdReports as a baseline, RIDE's list includes only curricula that are rated "Green" in all three gateways: (1 & 2) alignment to standards with depth and quality in the content area, and (3) usability of instructional materials for teachers and students. Because EdReports' gateways comprise many indicators, which provide more in-depth looks across the integral components of instructional materials, it is important to note that having a "Green-rated" curriculum is a solid foundation, yet not enough on its own to ensure alignment to local instructional priorities and students' needs. The curriculum adoption process should include consideration of an LEA's instructional vision, multilingual learner (MLL) needs, and culturally responsive and sustaining education (CRSE). Selection is only the starting point in the larger process of adoption and implementation of high-quality instructional materials. LEAs should consider curriculum adoption and implementation an iterative process where the efficacy of a curriculum is reviewed and evaluated on an ongoing basis.

Coherence is one major consideration when adopting a new curriculum. One way of achieving coherence is the vertical articulation in a set of materials, or the transition and connection of skills, content, and pedagogy from grade to grade. Consideration of coherence is necessary to ensure that students experience a learning progression of skills and content that build over time through elementary, middle, and high school. As such, LEAs who consider the adoption of curriculum materials are cautioned against choosing a curriculum that is high quality at only one grade level, as it is likely it will disrupt a cohesive experience in the learning progression from grade to grade in the school or district.

While the standards describe what students should know and be able to do, they do not dictate how they should be taught, or the materials that should be used to teach and assess those (NGA & CCSSO, 2010). Curriculum materials, when aligned to the standards, provide students with varied opportunities to gain the knowledge and skills outlined by the standards. Assessments, when aligned to the standards, have the goal of understanding how student learning is progressing toward acquiring proficiency in the knowledge and skills outlined by the standards as delivered by the curriculum through instruction (CSAI, 2018).

No set of grade-level standards can reflect the great variety of abilities, needs, learning rates, and achievement levels in any given classroom. The standards define neither the support materials that some students may need nor the advanced materials that others should have access to. It is also beyond the scope of the standards to define the full range of support appropriate for MLLs and for differently-abled students. Still, all students must have the opportunity to learn and meet the same high standards if they are to access the knowledge and skills that will be necessary in their postsecondary lives. The standards should be read as allowing for the widest possible range of students to participate fully from the outset with appropriate accommodations to ensure maximum participation of students, particularly those from historically underserved populations (MDOE, 2017).

Having access to HQCMs is an important component of increasing equitable access to a rigorous education that prepares every student for college and careers.

College and Career Readiness

RIDE's mission for College and Career Readiness is to build an education system in Rhode Island that prepares all students for success in college and career. This means that all doors remain open and students are prepared for whatever their next steps may be after high school.

Secondary education, which begins in middle school and extends through high school graduation, is the point in the educational continuum where students experience greater choice on their journey to college and career readiness. Students have access to a wide range of high-quality personalized learning opportunities and academic coursework, and have a variety of options available to complete their graduation requirements. To improve student engagement and increase the relevance of academic content, students may choose to pursue a number of courses and learning experiences that align to a particular area of interest, including through dedicated career and technical education programs or early college coursework opportunities.

Secondary level students have opportunities to be able to control the pace, place, and content of their learning experience while meeting state and local requirements. Rhode Island middle and high school students will have access to a wide range of high-quality early college and early career training programs that enable them to earn high-value, portable credit and credentials.

Next Generation Science Standards Commitment to CCR

The following information is summarized from the nextgenscience.org, NGSS Lead States (2013). A deeper dive into How NGSS is committed to College and Career Readiness can be found in [Appendix C: College and Career Readiness,] NGSS Lead States (2013).

Rigorous standards designed to support college and career readiness provide equitable access and lead to a deep understanding of content for students when high-quality instructional materials are aligned, coherent, and incorporate effective teaching and learning practices.

- A high-quality, robust science education means students will develop an in-depth understanding of content and will gain knowledge and develop skills — communication, collaboration, inquiry, problem solving, and flexibility — that will serve them throughout their educational and professional lives.[2]
- High-quality STEM (science, technology, engineering and mathematics) standards allow educators to teach effectively, moving their practice toward how students learn best — in a hands-on, collaborative, and integrated environment rooted in inquiry and discovery. The NGSS require thinking and reasoning rather than rote memorization.[2]
- The definition of what it means to be "literate" in science continues to grow and now includes the use of technology, critical thinking, and analytical skills. As citizens, we are increasingly asked to make informed decisions on issues ranging from healthcare to energy policy that affect ourselves, our families, and our communities. Having a deep

[2] "Next Generation Science Standards Fact Sheet for Teachers," (2014) https://www.oregon.gov/ode/educator-resources/standards/science/Documents/ngss-fact-sheet---teachers-final-7-27-14.pdf

understanding of scientific concepts and processes and the ability to understand and apply this knowledge is essential.[2]

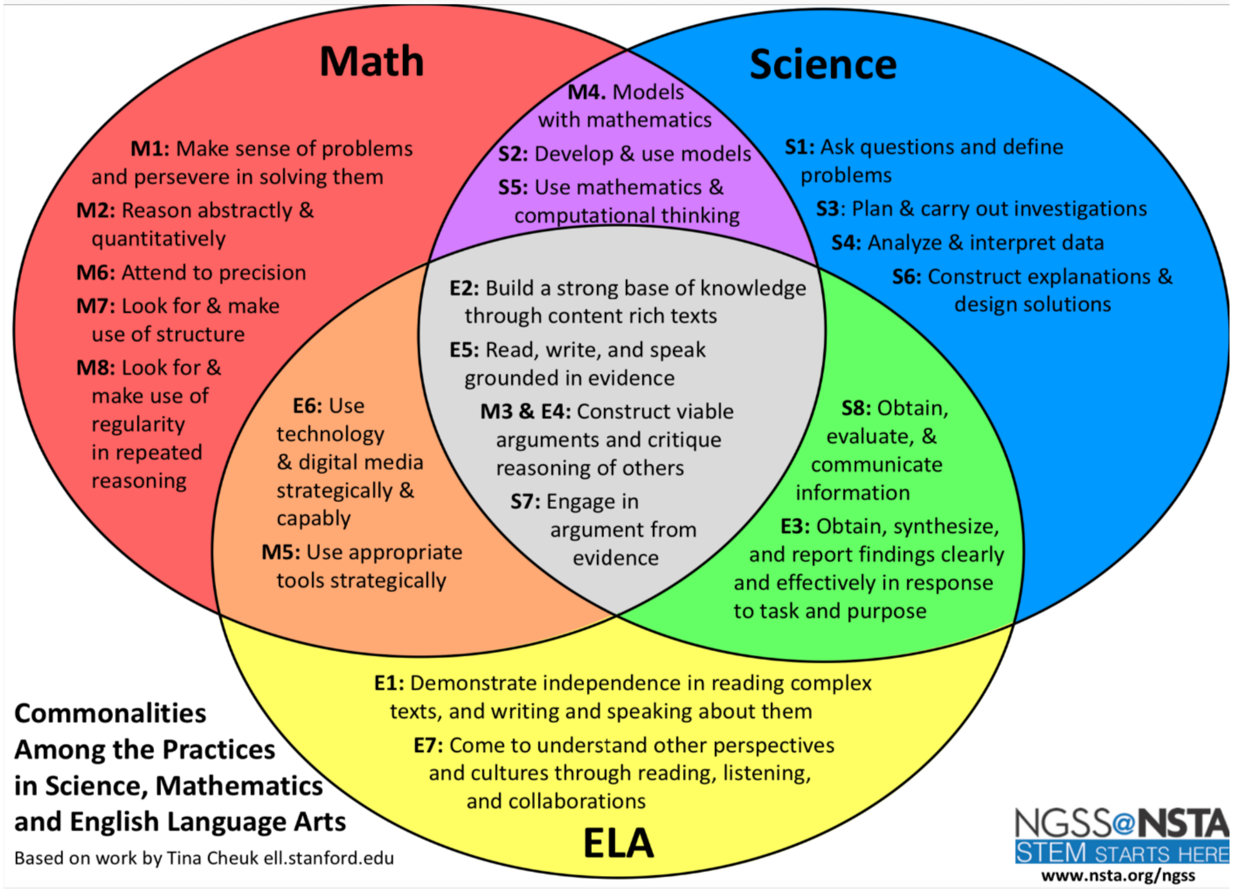
- Our nation's science teachers are finding that when educators raise expectations and give students the right tools and learning environment, students are capable of remarkable science literacy and achievement.[2]
- A strong science education equips students with skills that are necessary for all careers — within and beyond STEM fields. Students need the right foundation to tackle long-term and difficult issues that face our generation and future generations. [2]
- A high-quality, robust science education means students will develop an in-depth understanding of content and will gain knowledge and develop skills — communication, collaboration, inquiry, problem solving, flexibility — that will serve them throughout their educational and professional lives.[2]

The Science Standards

The organization of the *Next Generation Science Standards* is based on the core ideas in the major fields of natural science from the *Framework*, plus one set of performance expectations for engineering. The *Framework* lists 11 core ideas, four in life sciences, four in physical sciences, and three in Earth and space sciences. The core ideas are divided into a total of 39 sub-ideas, and each sub-idea is elaborated in a list of what students should understand about that sub-idea at the end of 2nd, 5th, 8th, and 11th grade. These grade-specific statements are called disciplinary core ideas.

Commonalities among the Practices in Mathematics and English Language Arts

The following resource[3] highlights the relationships and Convergences found in the Common Core State Standards in Mathematics (practices), Common Core State Standards in ELA/Literacy*(student portraits), and A Framework for K-12 Science Education (science & engineering practices). When reviewing the Next Generations Science Standards, note that they were designed to integrate developmentally appropriate Math and ELA standards to support language development accordingly.



[3] For a deeper dive in to how the standards work together, visit: https://static.nsta.org/ngss/ExplanationOfVennDiagram.pdf

The National Research Council's (NRC) *Framework* includes a vision of what it means for students to be proficient. It includes the idea that science is a body of evidence that is continually changing based on new evidence. This body of facts includes three domains that are considered when forming each standard, performance expectation as described in NGSS Lead States (2013).

The following introduction is adapted directly from NGSS Lead States, Three-Dimensions (2013).

Dimension 1: Science and Engineering Practices

The practices describe behaviors that scientists engage in as they investigate and build models and theories about the natural world and the key set of engineering practices that engineers use as they design and build models and systems. The NRC uses the term “practices” instead of a term like “skills” to emphasize that engaging in scientific investigation requires not only skill, but also knowledge that is specific to each practice. Part of the NRC’s intent is to better explain and extend what is meant by “inquiry” in science and the range of cognitive, social, and physical practices that it requires.

Although engineering design is similar to scientific inquiry, there are significant differences. For example, scientific inquiry involves the formulation of a question that can be answered through investigation, while engineering design involves the formulation of a problem that can be solved through design. The engineering aspects of the Next Generation Science Standards will clarify for students the relevance of science, technology, engineering and mathematics (the four STEM fields) to everyday life and how engineers design solutions based on specific criteria and constraints (paras. 2-3).

Dimension 2 Crosscutting Concepts

Crosscutting concepts have application across all domains of science. As such, they are a way of linking the different domains of science. They include: Patterns; Cause and effect; Scale, proportion and quantity; Systems and system models; Energy and matter; Structure and function; Stability and change. The Framework emphasizes that these concepts need to be made explicit for students because they provide an organizational schema for interrelating knowledge from various science fields into a coherent and scientifically-based view of the world (para4).

Dimension 3: Disciplinary Core Ideas

Disciplinary core ideas have the power to focus K–12 science curriculum, instruction and assessments on the most important aspects of science. To be considered core, the ideas should meet at least two of the following criteria and ideally all four:

- Have broad importance across multiple sciences or engineering disciplines or be a key organizing concept of a single discipline;
- Provide a key tool for understanding or investigating more complex ideas and solving problems;
- Relate to the interests and life experiences of students or be connected to societal or personal concerns that require scientific or technological knowledge; and
- Be teachable and learnable over multiple grades at increasing levels of depth and sophistication (paras. 25-6).

In addition to the standards being three-dimensional, NGSS are committed to the integration of Engineering Design Standards. The Engineering standards are integrated K–12, in the context of specific Performance Expectations and are implemented with the same three-dimensional approach (Lead States, Appendix I, 2013).

"…studying and engaging in the practices of science and engineering during their K–12 schooling should help students see how science and engineering are instrumental in addressing major challenges that confront society today, such as generating sufficient energy, preventing and treating diseases, maintaining supplies of clean water and food, and solving the problems of global environmental change." (NRC Framework, 2012, p. 9).

To dive deeper into the role of Engineering Design in NGSS, please visit NGSS Appendix I.

A Science Framework for K–12 Science Education (2012) provides the blueprint for developing the NGSS. The Framework expresses a vision in science education that requires students to operate at the nexus of three dimensions of learning: Science and Engineering Practices **(SEPs)**, Crosscutting Concepts **(CCCs)**, and Disciplinary Core Ideas **(DCIs)**. The Framework identified a small number of disciplinary core ideas that all students should learn with increasing depth and sophistication, from kindergarten through 12th grade. Key to the vision expressed in the Framework is for students to learn these disciplinary core ideas in the context of science and engineering practices. The importance of combining science and engineering practices and disciplinary core ideas is stated in the Framework as follows:

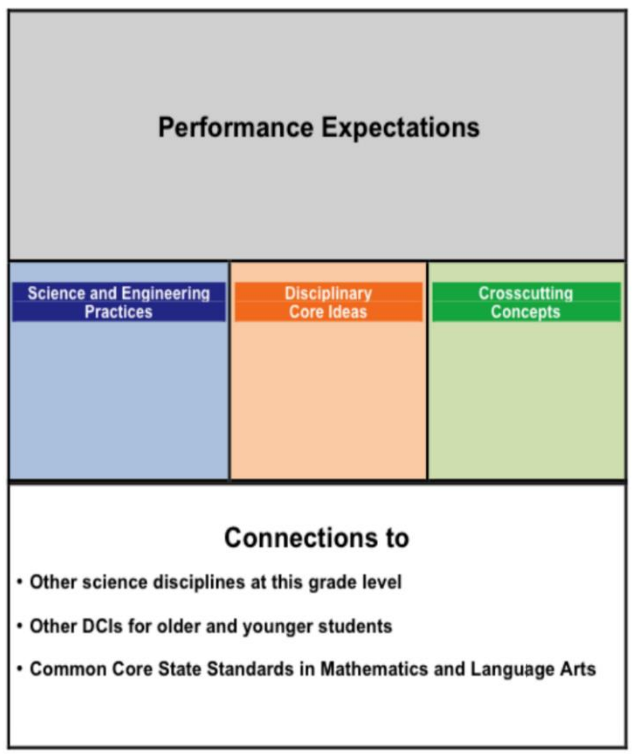
"Standards and performance expectations that are aligned to the framework must take into account that students cannot fully understand scientific and engineering ideas without engaging in the practices of inquiry and the discourses by which such ideas are developed and refined. At the same time, they cannot learn or show competence in practices except in the context of specific content." (NRC Framework, 2012, p. 218)

How to Read the Standards

The following overview of how to read the standards is adapted from NGSS Lead States (2013). The Next Generation Science Standards: For States by States, [How to Read NGSS](). Retrieved from https://www.nextgenscience.org.

The Next Generation Science Standards (NGSS) are distinct from prior science standards in three essential ways.

1. **Performance.** Prior standards documents listed what students should "know" or "understand." These ideas needed to be translated into performances that could be assessed to determine whether or not students met the standard. Different interpretations sometimes resulted in assessments that were not aligned with curriculum and instruction. The NGSS has avoided this difficulty by developing performance expectations that state what students should be able to do in order to demonstrate that they have met the standard, thus providing the same clear and specific targets for curriculum, instruction, and assessment.
2. **Foundations.** Each performance expectation incorporates all three dimensions from the Framework — a science and engineering practice, a core disciplinary idea, and a crosscutting concept.
3. **Coherence.** Each set of performance expectations lists connections to other ideas within the disciplines of science and engineering, and with Common Core State Standards in Mathematics and English Language Arts.



See comprehensive glossary for NGSS frequently used terminology: https://www.nextgenscience.org/glossary

System Architecture

As shown in the illustration below, each set of performance expectations has a title. Below the title is a box containing the performance expectations. Below that are three foundation boxes, which list (from left to right) the specific science and engineering practices, disciplinary core ideas (DCIs), and crosscutting concepts that were combined to produce the performance expectations (PEs) above. The bottom section lists connections to other related DCIs at the same grade level, to related DCIs for younger and older students, and to related Common Core State Standards in mathematics and language arts. These sections *are described in further detail below (How to Read NGSS, 2013, p.1).*

Performance Expectations

Performance expectations are the assessable statements of what students should know and be able to do. All students should be held accountable for demonstrating their achievement of all performance expectations, which are written to allow for multiple means of assessment.

The last sentence in the above paragraph — that all students should be held accountable for demonstrating their achievement of all performance expectations — deserves special attention because it is a fundamental departure from prior standards documents, especially at the high school level where it has become customary for students to take courses in some, but not all science disciplines. The NGSS takes the position that a scientifically literate person understands and is able to apply core ideas in each of the major science disciplines, and that they gain experience in the practices of science and engineering and crosscutting concepts. In order for this to be feasible, the writing team has limited the core ideas included in the PEs to just those listed in the Framework.

The NGSS are for all students, and all students are expected to achieve proficiency with respect to all of the PEs in the NGSS.

A second essential point is that the NGSS PEs should not limit the curriculum. Students interested in pursuing science further (through Advanced Placement or other advanced courses) should have the opportunity to do so. The NGSS PEs provide a foundation for rigorous advanced courses in science or engineering that some students may choose to take.

A third point is that the PEs are not a set of instructional or assessment tasks. They are statements of what students should be able to do after instruction. Decisions on how best to help students meet these PEs are left to states, districts, and teachers.

In the example below, notice how the PE combines the skills and ideas that students need to learn, while it suggests ways of assessing whether or not second graders have the capabilities and understandings specified in the three foundation boxes *(How to Read*

NGSS, 2013, p.2).

2.Structure and Properties of Matter

2.Structure and Properties of Matter

Students who demonstrate understanding can:

2-PS1-2. Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose.* [Clarification Statement: Examples of properties could include, strength, flexibility, hardness, texture, and absorbency.] [Assessment Boundary: Assessment of quantitative measurements is limited to length.]

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

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data Analyzing data in K–2 builds on prior experiences and progresses to collecting, recording, and sharing observations. ▪ Analyze data from tests of an object or tool to determine if it works as intended. (2-PS1-2)	**PS1.A: Structure and Properties of Matter** ▪ Different properties are suited to different purposes. (2-PS1-2)	**Cause and Effect** ▪ Simple tests can be designed to gather evidence to support or refute student ideas about causes. (2-PS1-2) --------------------------------- ***Connections to Engineering, Technology, and Applications of Science*** **Influence of Engineering, Technology, and Science on Society and the Natural World** ▪ Every human-made product is designed by applying some knowledge of the natural world and is built using materials derived from the natural world. (2-PS1-2)

Connections to other DCIs in second grade: N/A

Articulation of DCIs across grade-levels: **5.PS1.A** (2-PS1-2)

Common Core State Standards Connections:

ELA/Literacy –

RI.2.8	Describe how reasons support specific points the author makes in a text. *(2-PS1-2)*
W.2.7	Participate in shared research and writing projects (e.g., read a number of books on a single topic to produce a report; record science observations). (2-PS1-2)
W.2.8	Recall information from experiences or gather information from provided sources to answer a question. (2-PS1-2)

Mathematics –

MP.2	Reason abstractly and quantitatively. *(2-PS1-2)*
MP.4	Model with mathematics. *(2-PS1-2)*
MP.5	Use appropriate tools strategically. *(2-PS1-2)*
2.MD.D.10	Draw a picture graph and a bar graph (with single-unit scale) to represent a data set with up to four categories. Solve simple put-together, take-apart, and compare problems using information presented in a bar graph. *(2-PS1-2)*

As shown in the example, most of the PEs are followed by one or two additional statements in smaller type. These include clarification statements, which supply examples or additional clarification to the PEs, and assessment boundary statements, which specify the limits to large scale assessment.

Notice that the code for this **performance expectation (2-PS1-2)** is indicated in each of the three foundation boxes to illustrate the specific practices, disciplinary core ideas, and crosscutting concepts on which it is built. Since most of the pages have several PEs, the codes make it easy to see how the information in the foundation boxes is used to construct each PE.

The codes for the PEs were derived from the Framework. As with the titles, the first digit indicates a grade (K-5) or specifies MS (middle school) or HS (high school). The next alpha-numeric code specifies the discipline, core idea and sub-idea. All of these codes are shown in the table below, derived from the Framework. Finally, the number at the end of each code indicates the order in which that statement appeared as a DCI in the Framework.

Physical Science	Life Science	Earth and Space Science
PS1 Matter and Its Interactions	**LS1 From Molecules to Organisms: Structures and Processes**	**ESS1 Earth's Place in the Universe**
PS1A Structure and Properties of matter	LS1A Structure and Function	ESS1A The Universe and Its Stars
PS1B Chemical Reactions	LS1B Growth and Development of Organisms	ESS1B Earth and the Solar System
PS1C Nuclear Processes	LS1C Organization for Matter and Energy Flow in Organisms	ESS1C The History of Planet Earth
PS2 Motion and Stability: Forces and Interactions	LS1D Information Processing	**ESS2 Earth's Systems**
PS2A Forces and Motion	**LS2 Ecosystems: Interactions, Energy, and Dynamics**	ESS2A Earth Materials and Systems
PS2B Types of Interactions	LS2A Interdependent Relationships in Ecosystems	ESS2B Plate Tectonics and Large-Scale System Interactions
PS2C Stability and Instability in Physical Systems	LS2B Cycles of Matter and Energy Transfer in Ecosystems	ESS2C The Roles of Water in Earth's Surface Processes
PS3 Energy	LS2C Ecosystem Dynamics, Functioning, and Resilience	ESS2D Weather and Climate
PS3A Definitions of Energy	LS2D Social Interactions and Group Behavior	ESS2E Biogeology
PS3B Conservation of Energy and Energy Transfer	**LS3 Heredity: Inheritance and Variation of Traits**	**ESS3 Earth and Human Activity**
PS3C Relationship Between Energy and Forces	LS3A Inheritance of Traits	ESS3A Natural Resources
PS3D Energy and Chemical Processes in Everyday Life	LS3B Variation of Traits	ESS3B Natural Hazards
PS4 Waves and Their Applications in Technologies for Information Transfer	**LS4 Biological Evolution: Unity and Diversity**	ESS3C Human Impacts on Earth Systems
PS4 Waves and Their Applications in Technologies for Information Transfer	LS4A Evidence of Common Ancestry	ESS3D Global Climate Change
PS4A Wave Properties	LS4B Natural Selection	
PS4B Electromagnetic Radiation	LS4C Adaptation	
PS4C Information Technologies and Instrumentation	LS4D Biodiversity and Humans	

(*How to Read NGSS*, *2013, p.3)*

Foundation Boxes

While the PEs could be listed without all three dimensions, a more coherent and complete view of what students should be able to do comes when the PEs are viewed in tandem with the contents of the foundation boxes that lie just below the PEs. These three boxes include the practices, core disciplinary ideas, and crosscutting concepts, derived from the Framework, that were used to construct this set of PEs.

Science and Engineering Practices (SEPs) The blue box on the left includes just the science and engineering practices used to construct the PEs in the box above. These statements are derived from and grouped by the eight categories detailed in the Framework to further explain the science and engineering practices important to emphasize in each grade band. Most sets of PEs emphasize only a few of the practice categories; however, all practices are emphasized within a grade band. Teachers should be encouraged to utilize several practices in any instruction and need not be limited by the PE, which is only intended to guide assessment.

Disciplinary Core Ideas (DCIs). The orange box in the middle includes statements that are taken from the Framework about the most essential ideas in the major science disciplines that all students should understand during 13 years of school. Including these detailed statements was very helpful to the NGSS writing team as they analyzed and "unpacked" the disciplinary core ideas and sub-ideas to reach a level that is helpful in describing what each student should understand about each sub-idea at the end of 2nd, 5th, 8th, and 12th grade. Although they appear in paragraph form in the Framework, here they are bulleted to be certain that each statement is distinct.

Crosscutting Concepts (CCCs). The green box on the right includes statements derived from the Framework's list of crosscutting concepts, which apply to one or more of the PEs in the box above. Most sets of PEs limit the number of crosscutting concepts so as to focus on those that are readily apparent when considering the DCIs. However, all are emphasized within a grade band. Again, the list is not exhaustive nor is it intended to limit instruction. Aspects of the Nature of Science relevant to the standard are also listed in this box, as are the interdependence of science and engineering, and the influence of engineering, technology, and science on society and the natural world. Although these are not crosscutting concepts in the same sense as the others, they are best taught and assessed in the context of specific science ideas, so they are also listed in this box.

Connection Boxes

Three Connection Boxes, below the Foundation Boxes, are designed to support a coherent vision of the standards by showing how the PEs in each standard connect to other PEs in science, as well as to common core state standards. The three boxes include:

Connections to other DCIs in this grade level. This box contains the names of DCIs that have related disciplinary core ideas at the same grade level. For example, both Physical Science and Life Science PEs contain core ideas related to Photosynthesis and could be taught in relation to one another. Ideas within the same main DCI as the PE (e.g., PS1.C for HS-PS1-1) are not included in the connection box, nor are ideas within the same topic arrangement as a PE (e.g., HS.ESS2.B for HS-ESS1-6).

Articulation of DCIs across grade levels. This box contains the names of DCIs that either 1) provide a foundation for student understanding of the core ideas in this PE (usually at prior grade levels) or 2) build on the foundation provided by the core ideas in this PE (usually at subsequent grade levels).

Connections to the Common Core State Standards. This box contains the coding and names of prerequisite or connected Common Core State Standards in English Language Arts & and Literacy and Mathematics that align to the PEs. For example, PEs that require student use of exponential notation will align to the corresponding CCSS mathematics standards. An effort has been made to ensure that the mathematical skills that students need for science were taught in a previous year where possible. Italicized performance expectation names indicate that the common core standard is not prerequisite knowledge, but could be connected to that PE.

Color Coding

Online versions of the standards display color coding of the words within each performance expectation that represent the three dimensions: blue for Science and Engineering Practices, orange for Disciplinary Core Ideas, and green for Crosscutting Concepts. Clarification Statements and Assessment Boundaries are in red. Because some of the words used in the performance expectation represented both a crosscutting concept and the disciplinary core idea, it was not possible to color code both simultaneously.

Printed and PDF versions of the standards may not have color coding of the three dimensions. In these cases, the connections between individual performance expectations and the statements in the foundation boxes will be shown by including the relevant codes after each statement in the foundation boxes.

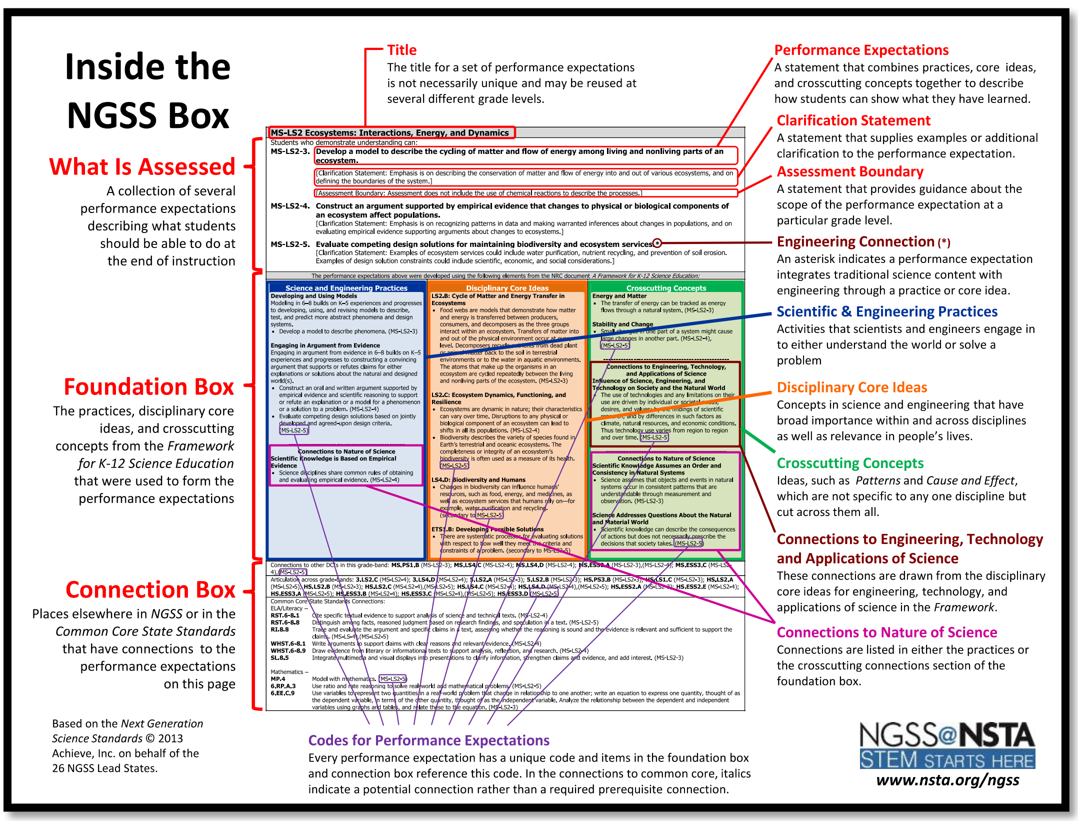
Title

The organization of the NGSS is based on the core ideas in the major fields of natural science from A Framework for K-12 Science Education (NRC, 2012), plus one set of PEs for engineering. For the elementary level, from kindergarten to 5th grade, sets of performance expectations are assigned to specific grades. A numeral at the start of a title indicates the grade level; so, the title in the example above is a third-grade standard. Titles for middle school (6th-8th grade) standards begin with “MS” and those for high school standards (9th-12th grade) begin with “HS.”

The titles also reveal the organization of the standards, which is based on the core ideas in the disciplines from the Framework. The Framework lists 11 core ideas, four in life science, four in physical science, and three in Earth and Space Science. The core ideas are divided into a total of 39 sub-ideas, and each sub-idea is elaborated in a list of what students should understand about that sub-idea at the end of 2nd, 5th, 8th, and 11th grade. We have called these grade-specific statements Disciplinary Core Ideas (DCIs).

At the beginning of the process, the writers examined all of the DCIs in the Framework to eliminate redundant statements, find natural connections among DCIs, and develop PEs that were appropriate for the different grade levels. The result was a topical clustering of DCIs that usually, but did not always correspond to the core ideas identified in the Framework. This structure provided the original basis of the standards and has continued through the process ([How to Read NGSS](#) 2013, pp.4-5)

Click [Inside the NGSS Box Link for a Closer look](#)



Source: A Look at the Next Generation Science Standards. (2013).

Resources to Help Educators Understand the Standards

- Video Resource: How to Read the Next Generation Science Standards
- Common Acronyms used by the NGSS
- A comprehensive glossary for NGSS: https://www.nextgenscience.org/glossary
- Infographic of Inside the Box: https://static.nsta.org/ngss/resources/InsideTheNGSSBox.pdf

Science and Engineering Practices (SEPs)

The following overview of the Science and Engineering Practices was modified from NGSS Lead States (2013). The Next Generation Science Standards: For States by States, Appendix F. Retrieved from https://www.nextgenscience.org. (2013).

The Framework specifies that each performance expectation must combine a relevant practice of science or engineering, with a core disciplinary idea and crosscutting concept, appropriate for students of the designated grade level. That guideline is perhaps the most significant way in which the NGSS differs from prior standards documents. Science assessments should not assess students' understanding of core ideas separately from their abilities to use the practices of science and engineering. They should be assessed together, showing students not only "know" science concepts; but also, students can use their understanding to investigate the natural world through the practices of science inquiry, or solve meaningful problems through the practices of engineering design. The *Framework uses the term "practices" rather than "science processes" or "inquiry" skills for a specific reason:*

We use the term "practices" instead of a term such as "skills" to emphasize that engaging in scientific investigation requires not only skill but also knowledge that is specific to each practice. (NRC Framework, 2012, p. 30)

The eight practices of science and engineering that the Framework identifies as essential for all students to learn and describes in detail are listed below:

1. *Asking questions (for science) and defining problems (for engineering)*
2. *Developing and using models*
3. *Planning and carrying out investigations*
4. *Analyzing and interpreting data*
5. *Using mathematics and computational thinking*
6. *Constructing explanations (for science) and designing solutions (for engineering)*
7. *Engaging in argument from evidence*
8. *Obtaining, evaluating, and communicating information*

Rationale

Chapter 3 of the Framework (NRC, 2012), describes each of the eight practices of science and engineering and presents the following rationale for why they are essential.

Engaging in the practices of science helps students understand how scientific knowledge develops; such direct involvement gives them an appreciation of the wide range of approaches that are used to investigate, model, and explain the world. Engaging in the *practices of engineering likewise helps students understand the work of engineers, as well as the links between engineering and science. Participation in these practices (also April 2013 NGSS Release Page 2 of 33) helps students form an understanding of the crosscutting concepts and disciplinary ideas of science and engineering; moreover, it makes students' knowledge more meaningful and embeds it more deeply into their worldview. The actual doing of science or engineering can also pique students' curiosity, capture their interest, and motivate their continued study; the insights thus gained help them recognize that the work of scientists and engineers is a creative endeavor—one that has deeply affected the world they live in. Any education that focuses predominantly on the detailed products of scientific labor—the facts of science—without developing an understanding of how those facts were established or that ignores the many important applications of science in the world misrepresents science and marginalizes the importance of engineering. (NRC Framework 2012, pp. 42-43)*

As suggested in the rationale above, Chapter 3 derives the eight practices based on an analysis of what professional scientists and engineers do. The "Practices Matrix" is included, which lists the specific capabilities included in each practice for each grade band (K–2, 3–5, 6–8, and 9–12).

Guiding Principles

The development process of the standards provided insights into science and engineering practices. These insights are shared in the following guiding principles:

Students in grades K–12 should engage in all eight practices over each grade band. All eight practices are accessible at some level to young children; students' abilities to use the practices grow over time. However, the NGSS only identifies the capabilities students are expected to acquire by the end of each grade band (K–2, 3–5, 6–8, and 9–12). Curriculum developers and teachers determine strategies that advance students' abilities to use the practices.

Practices grow in complexity and sophistication across the grades. The Framework suggests how students' capabilities to use each of the practices should progress as they mature and engage in science learning. For example, the practice of "planning and carrying out investigations" begins at the kindergarten level with guided situations in which students have assistance in identifying phenomena to be investigated, and how to observe, measure, and record outcomes. By upper elementary school, students should be able to plan their own investigations. The nature of investigations that students should be able to plan and carry out is also expected to increase as students mature, including the complexity of questions to be studied, the ability to determine what kind of investigation is needed to answer different kinds of questions, whether or not variables need to be controlled and if so, which are most important, and at the high school level, how to take measurement error into account. As listed in the tables in this chapter, each of the eight practices has its own progression, from kindergarten to 12th grade. While these progressions are derived from Chapter 3 of the Framework, they are refined based on experiences in crafting the NGSS and feedback received from reviewers.

Each practice may reflect science or engineering. Each of the eight practices can be used in the service of scientific inquiry or engineering design. The best way to ensure a practice is being used for science or engineering is to ask about the goal of the activity. Is the goal to answer a question? If so, students are doing science. Is the purpose to define and solve a problem? If so, students are doing engineering.

Practices represent what students are expected to do and are not teaching methods or curriculum. The Framework occasionally offers suggestions for instruction, such as how a science unit might begin with a scientific investigation, which then leads to the solution of an engineering problem. The NGSS avoids such suggestions since the goal is to describe what students should be able to do, rather than how they should be taught. For example, it was suggested for the NGSS to recommend certain teaching strategies such as using biomimicry—the application of biological features to solve engineering design problems. Although instructional units that make use of biomimicry seem well-aligned with the spirit of the Framework to encourage integration of core ideas and practices, biomimicry and similar teaching approaches are more closely related to curriculum and instruction than to assessment. Hence, the decision was made not to include biomimicry in the NGSS.

The eight practices are not separate; they intentionally overlap and interconnect. As explained by Bell, et al. (2012), the eight practices do not operate in isolation. Rather, they tend to unfold sequentially, and even overlap. For example, the practice of "asking questions" may lead to the practice of "modeling" or "planning and carrying out an investigation," which in turn may lead to "analyzing and interpreting data." The practice of "mathematical and computational thinking" may include some aspects of "analyzing and interpreting data." Just as it is important for students to carry out each of the individual practices, it is important for them to see the connections among the eight practices.

Performance expectations focus on some, but not all capabilities associated with a practice. The Framework identifies a number of features or components of each practice. The practices matrix, described in this section, lists the components of each practice as a bulleted list within each grade band. As the performance expectations were developed, it became clear that it's too much to expect each performance to reflect all components of a given practice. The most appropriate aspect of the practice is identified for each performance expectation.

Engagement in practices is language intensive and requires students to participate in classroom science discourse. The practices offer rich opportunities and demands for language learning while advancing science learning for all students (Lee, Quinn, & Valdés, 2013). English language learners, students with disabilities that involve language processing, students with limited literacy development, and students who are speakers of social or regional varieties of English that are generally referred to as "non-Standard English" stand to gain from science learning that involves language-intensive scientific and engineering practices. When supported appropriately, these students are capable of learning science through their emerging language and comprehending and carrying out sophisticated language functions (e.g., arguing from evidence, providing explanations, developing models) using less-than-perfect English. By engaging in such practices, moreover, they simultaneously build on their understanding of science and their language proficiency (i.e., capacity to do more with language).

On the following pages, each of the eight practices is briefly described. Each description ends with a table illustrating the components of the practice that students are expected to master at the end of each grade band. All eight tables comprise the practices matrix. During development of the NGSS, the practices matrix was revised several times to reflect improved understanding of how the practices connect with the disciplinary core ideas (NGSS Lead States, Appendix F, 2013, pp. 1-3).

Practice 1 Asking Questions and Defining Problems

Students at any grade level should be able to ask questions of each other about the texts they read, the features of the phenomena they observe, and the conclusions they draw from their models or scientific investigations. For engineering, they should ask questions to define the problem to be solved and to elicit ideas that lead to the constraints and specifications for its solution. (NRC Framework 2012, p. 56)

Scientific questions arise in a variety of ways. They can be driven by curiosity about the world, inspired by the predictions of a model, theory, or findings from previous investigations, or they can be stimulated by the need to solve a problem. Scientific questions are distinguished from other types of questions in that the answers lie in explanations supported by empirical evidence, including evidence gathered by others or through investigation.

While science begins with questions, engineering begins with defining a problem to solve. However, engineering may also involve asking questions to define a problem, such as: What is the need or desire that underlies the problem? What are the criteria for a successful solution? Other questions arise when generating ideas, or testing possible solutions, such as: What are the possible trade-offs? What evidence is necessary to determine which solution is best?

Asking questions and defining problems also involves asking questions about data, claims that are made, and proposed designs. It is important to realize that asking a question also leads to involvement in another practice. A student can ask a question about data that will lead to further analysis and interpretation. Or a student might ask a question that leads to planning and design, an investigation, or the refinement of a design.

Whether engaged in science or engineering, the ability to ask good questions and clearly define problems is essential for everyone. The following progression of Practice 1 summarizes what students should be able to do by the end of each grade band. Each of the examples of asking questions below leads to students engaging in other scientific practices (NGSS Lead States, Appendix F, 2013, p. 4).

Practice 1 Asking Questions and Defining Problems Progressions Matrix p. 4

Practice 2 Developing and Using Models

Modeling can begin in the earliest grades, with students' models progressing from concrete "pictures" and/or physical scale models (e.g., a toy car) to more abstract representations of relevant relationships in later grades, such as a diagram representing forces on a particular object in a system. (NRC Framework, 2012, p. 58)

Models include diagrams, physical replicas, mathematical representations, analogies, and computer simulations. Although models do not correspond exactly to the real world, they bring certain features into focus while obscuring others. All models contain approximations and assumptions that limit the range of validity and predictive power, so it is important for students to recognize their limitations.

In science, models are used to represent a system (or parts of a system) under study, to aid in the development of questions and explanations, to generate data that can be used to make predictions, and to communicate ideas to others. Students can be expected to evaluate and refine models through an iterative cycle of comparing their predictions with the real world and then adjusting them to gain insights into the phenomenon being modeled. As such, models are based upon evidence. When new evidence is uncovered that the models can't explain, models are modified.

In engineering, models may be used to analyze a system to see where or under what conditions flaws might develop, or to test possible solutions to a problem. Models can also be used to visualize and refine a design, to communicate a design's features to others, and as prototypes for testing design performance (NGSS Lead States, Appendix F, 2013, p. 6).

Practice 2 Developing and Using Models Progression Matrix p. 6

Practice 3 Planning and Carrying Out Investigations

Students should have opportunities to plan and carry out several different kinds of investigations during their K–12 years. At all levels, they should engage in investigations that range from those structured by the teacher—in order to expose an issue or question that they would be unlikely to explore on their own (e.g., measuring specific properties of materials)—to those that emerge from students' own questions. (NRC Framework, 2012, p. 61)

Scientific investigations may be undertaken to describe a phenomenon, or to test a theory or model for how the world works. The purpose of engineering investigations might be to find out how to fix or improve the functioning of a technological system or to compare different solutions to see which best solves a problem. Whether students are doing science or engineering, it is always important for them to state the goal of an investigation, predict outcomes, and plan a course of action that will provide the best evidence to support their conclusions. Students should design investigations that generate data to provide evidence to support claims they make about phenomena. Data aren't evidence until used in the process of supporting a claim. Students should use reasoning and scientific ideas, principles, and theories to show why data can be considered evidence.

Over time, students are expected to become more systematic and careful in their methods. In laboratory experiments, students are expected to decide which variables should be treated as results or outputs, which should be treated as inputs and intentionally varied from trial to trial, and which should be controlled, or kept the same across trials. In the case of field observations, planning involves deciding how to collect different samples of data under different conditions, even though not all conditions are under the direct control of the investigator. Planning and carrying out investigations may include elements of all of the other practices (NGSS Lead States, Appendix F, 2013, p. 7).

Practice 3 Planning and Carrying Out Investigations Progression Matrix p. 7

Practice 4 Analyzing and Interpreting Data

Once collected, data must be presented in a form that can reveal any patterns and relationships and that allows results to be communicated to others. Because raw data as such have little meaning, a major practice of scientists is to organize and interpret data through tabulating, graphing, or statistical analysis. Such analysis can bring out the meaning of data—and their relevance—so that they may be used as evidence. Engineers, too, make decisions based on evidence that a given design will work; they rarely rely on *trial and error. Engineers often analyze a design by creating a model or prototype and collecting extensive data on how it performs, including under extreme conditions. Analysis of this kind of data not only informs design decisions and enables the prediction or assessment of performance but also helps define or clarify problems, determine economic feasibility, evaluate alternatives, and investigate failures. (NRC Framework, 2012, pp. 61-62)*

As students mature, they are expected to expand their capabilities to use a range of tools for tabulation, graphical representation, visualization, and statistical analysis. Students are also expected to improve their abilities to interpret data by identifying significant features and patterns, use mathematics to represent relationships between variables, and take into account sources of error. When possible and feasible, students should use digital tools to analyze and interpret data. Whether analyzing data for the purpose of science or engineering, it is important students present data as evidence to support their conclusions (NGSS Lead States, Appendix F, 2013, p. 9).

Practice 4 Analyzing and Interpreting Data Progression Matrix p. 9

Practice 5 Using Mathematics and Computational Thinking

Although there are differences in how mathematics and computational thinking are applied in science and in engineering, mathematics often brings these two fields together by enabling engineers to apply the mathematical form of scientific theories and by enabling scientists to use powerful information technologies designed by engineers. Both kinds of professionals can thereby accomplish investigations and analyses and build complex models, which might otherwise be out of the question. (NRC Framework, 2012, p. 65)

Students are expected to use mathematics to represent physical variables and their relationships, and to make quantitative predictions. Other applications of mathematics in science and engineering include logic, geometry, and at the highest levels, calculus. Computers and digital tools can enhance the power of mathematics by automating calculations, approximating solutions to problems that cannot be calculated precisely, and analyzing large data sets available to identify meaningful patterns. Students are expected to use laboratory tools connected to computers for observing, measuring, recording, and processing data. Students are also expected to engage in computational thinking, which involves strategies for organizing and searching data, creating sequences of steps called algorithms, and using and developing new simulations of natural and designed systems. Mathematics is a tool that is key to understanding science. As such, classroom instruction must include critical skills of mathematics. The NGSS displays many of those skills through the performance expectations, but classroom instruction should enhance all of science through the use of quality mathematical and computational thinking (NGSS Lead States, Appendix F, 2013, p. 10).

Practice 5 Using Mathematics and Computational Thinking Progression Matrix p. 10

Practice 6 Constructing Explanations and Designing Solutions

The goal of science is to construct explanations for the causes of phenomena. Students are expected to construct their own explanations, as well as apply standard explanations they learn about from their teachers or reading. The Framework states the following about explanation:

The goal of science is the construction of theories that provide explanatory accounts of the world. A theory becomes accepted when it has multiple lines of empirical evidence and greater explanatory power of phenomena than previous theories. (NRC Framework, 2012, p. 52)

An explanation includes a claim that relates how a variable or variables relate to another variable or a set of variables. A claim is often made in response to a question and in the process of answering the question, scientists often design investigations to generate data.

The goal of engineering is to solve problems. Designing solutions to problems is a systematic process that involves defining the problem, then generating, testing, and improving solutions. This practice is described in the Framework as follows.

Asking students to demonstrate their own understanding of the implications of a scientific idea by developing their own explanations of phenomena, whether based on observations they have made or models they have developed, engages them in an essential part of the process by which conceptual change can occur.

In engineering, the goal is a design rather than an explanation. The process of developing a design is iterative and systematic, as is the process of developing an explanation or a theory in science. Engineers' activities, however, have elements that are distinct from those of scientists. These elements include specifying constraints and criteria for desired qualities of the solution, developing a design plan, producing and testing models or prototypes, selecting among alternative design features to optimize the achievement of design criteria, and refining design ideas based on the performance of a prototype or simulation. (NRC Framework, 2012, pp. 68-69)

[Practice 6 Constructing Explanations and Designing Solutions Progression Matrix p. 11]

Practice 7 Engaging in Argument from Evidence

The study of science and engineering should produce a sense of the process of argument necessary for advancing and defending a new idea or an explanation of a phenomenon and the norms for conducting such arguments. In that spirit, students should argue for the explanations they construct, defend their interpretations of the associated data, and advocate for the designs they propose. (NRC Framework, 2012, p. 73)

Argumentation is a process for reaching agreements about explanations and design solutions. In science, reasoning and argument based on evidence are essential in identifying the best explanation for a natural phenomenon. In engineering, reasoning and argument are needed to identify the best solution to a design problem. Student engagement in scientific argumentation is critical if students are to understand the culture in which scientists live, and how to apply science and engineering for the benefit of society. As such, argument is a process based on evidence and reasoning that leads to explanations acceptable by the scientific community and design solutions acceptable by the engineering community.

Argument in science goes beyond reaching agreements in explanations and design solutions. Whether investigating a phenomenon, testing a design, or constructing a model to provide a mechanism for an explanation, students are expected to use argumentation to listen to, compare, and evaluate competing ideas and methods based on their merits. Scientists and engineers engage in argumentation when investigating a phenomenon, testing a design solution, resolving questions about measurements, building data models, and using evidence to evaluate claims (NGSS Lead States, Appendix F, 2013, pp. 13-14)

Practice 7 Engaging in Argument from Evidence Progression Matrix p. 13

Practice 8 Obtaining, Evaluating, and Communicating Information

Any education in science and engineering needs to develop students' ability to read and produce domain-specific text. As such, every science or engineering lesson is in part a language lesson, particularly reading and producing the genres of texts that are intrinsic to science and engineering. (NRC Framework, 2012, p. 76)

Being able to read, interpret, and produce scientific and technical text are fundamental practices of science and engineering, as is the ability to communicate clearly and persuasively. Being a critical consumer of information about science and engineering requires the ability to read or view reports of scientific or technological advances or applications (whether found in the press, the Internet, or in a town meeting) and to recognize the salient ideas, identify sources of error and methodological flaws, distinguish observations from inferences, arguments from explanations, and claims from evidence. Scientists and engineers employ multiple sources to obtain information used to evaluate the merit and validity of claims, methods, and designs. Communicating information, evidence, and ideas can be done in multiple ways: using tables, diagrams, graphs, models, interactive displays, and equations as well as orally, in writing, and through extended discussions (NGSS Lead States, Appendix F, 2013, p.15).

Practice 8 Obtaining, Evaluating, and Communicating Information Progression Matrix p. 15

Reflecting on the Practices of Science and Engineering

Engaging students in the practices of science and engineering outlined in this section is not sufficient for scientific literacy. It is also important for students to stand back and reflect on how these practices have contributed to their own development, and to the accumulation of scientific knowledge and engineering accomplishments over the ages. Accomplishing this is a matter for curriculum and instruction, rather than standards, so specific guidelines are not provided in this document. Nonetheless, this section would not be complete without an acknowledgment that reflection is essential if students are to become aware of themselves as competent and confident learners and doers in the realms of science and engineering (NGSS Lead States, Appendix F, 2013, p. 16).

Resource

Website with print friendly pdfs of K–12 Progression of each Science and Engineering Practice Progression: NGSS Hub (nsta.org)

Crosscutting Concepts

The following overview of the Cross Cutting Concepts was modified from NGSS Lead States (2013). The Next Generation Science Standards: For States by States, Appendix G. Retrieved from https://www.nextgenscience.org.

A Framework for K–12 Science Education: Practices, Core Ideas, and Crosscutting Concepts (Framework) recommends science education in grades K–12 be built around three major dimensions: scientific and engineering practices; crosscutting concepts that unify the study of science and engineering through their common application across fields; and core ideas in the major disciplines of natural science. The purpose of this appendix is to describe the second dimension — crosscutting concepts — and to explain its role in the Next Generation Science Standards.

Crosscutting concepts have value because they provide students with connections and intellectual tools that are related across the differing areas of disciplinary content and can enrich their application of practices and their understanding of core ideas. — Framework, p. 233

The Framework identifies seven crosscutting concepts that bridge disciplinary boundaries, uniting core ideas throughout the fields of science and engineering. Their purpose is to help students deepen their understanding of the disciplinary core ideas (pp. 2 and 8) and develop a coherent and scientifically-based view of the world (p. 83). The seven crosscutting concepts presented in Chapter 4 of the Framework are as follows:

1. **Patterns:** Observed patterns of forms and events guide organization and classification, and they prompt questions about relationships and the factors that influence them.
2. **Cause and effect:** Mechanism and explanation. Events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts.
3. **Scale, proportion, and quantity:** In considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system's structure or performance.
4. **Systems and system models:** Defining the system under study — specifying its boundaries and making explicit a model of that system — provides tools for understanding and testing ideas that are applicable throughout science and engineering.
5. **Energy and matter:** Flows, cycles, and conservation. Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems' possibilities and limitations.
6. **Structure and function:** The way in which an object or living thing is shaped and its substructure determine many of its properties and functions.
7. **Stability and change:** For natural and built systems alike, conditions of stability and determinants of rates of change or evolution of a system are critical elements of study.

The Framework notes that crosscutting concepts are featured prominently in other documents about what all students should learn about science for the past two decades. These have been called "themes" in Science for All Americans (1989) and Benchmarks for Science Literacy (1993), "unifying principles" in National Science Education Standards (1996), and "crosscutting ideas" in NSTA's Science Anchors Project (2010). Although these ideas have been consistently included in previous standards documents, the Framework recognizes that "students have often been expected to build such knowledge without any explicit instructional support. Hence the purpose of highlighting them as Dimension 2 of the framework is to elevate their role in the development of standards, curricula, instruction, and assessments." (p. 83) The writing team has continued this commitment by weaving crosscutting concepts into the performance expectations for all students — so they cannot be left out.

Guiding Principles of the Cross Cutting Concepts

The Framework recommended crosscutting concepts be embedded in the science curriculum beginning in the earliest years of schooling and suggested a number of guiding principles for how they should be used. The development process of the standards provided insights into the crosscutting concepts. These insights are shared in the following guiding principles.

Crosscutting concepts can help students better understand core ideas in science and engineering. When students encounter new phenomena, whether in a science lab, field trip, or on their own, they need mental tools to help engage in and come to understand the phenomena from a scientific point of view. Familiarity with crosscutting concepts can provide that perspective. For example, when approaching a complex phenomenon (either a natural phenomenon or a machine), an approach that makes sense is to begin by observing and characterizing the phenomenon in terms of patterns. A next step might be to simplify the phenomenon by thinking of it as a system and modeling its components and how they interact. In some cases, it would be useful to study how energy and matter flow through the system, or to study how structure affects function (or malfunction). These preliminary studies may suggest explanations for the phenomena, which could be checked by predicting patterns that might emerge if the explanation is correct, and matching those predictions with those observed in the real world.

Crosscutting concepts can help students better understand science and engineering practices. Because the crosscutting concepts address the fundamental aspects of nature, they also inform the way humans attempt to understand it. Different crosscutting concepts align with different practices, and when students carry out these practices, they are often addressing one of these crosscutting concepts. For example, when students analyze and interpret data, they are often looking for patterns in observations, mathematical or visual. The practice of planning and carrying out an investigation is often aimed at identifying cause and effect relationships: if you poke or prod something, what will happen? The crosscutting concept of "Systems and System Models" is clearly related to the practice of developing and using models.

Repetition in different contexts will be necessary to build familiarity. Repetition is counter to the guiding principles the writing team used in creating performance expectations to reflect the core ideas in the science disciplines. In order to reduce the total amount of material students are held accountable to learn, repetition was reduced whenever possible. However, crosscutting concepts are repeated within grades at the elementary level and grade-bands at the middle and high school levels so these concepts "become common and familiar touchstones across the disciplines and grade levels." (p. 83)

Crosscutting concepts should grow in complexity and sophistication across the grades. Repetition alone is not sufficient. As students grow in their understanding of the science disciplines, depth of understanding crosscutting concepts should grow as well. The writing team has adapted and added to the ideas expressed in the Framework in developing a matrix for use in crafting performance expectations that describe student understanding of the crosscutting concepts. The matrix is found at the end of this section.

Crosscutting concepts can provide a common vocabulary for science and engineering. The practices, disciplinary core ideas, and crosscutting concepts are the same in science and engineering. What is different is how and why they are used — to explain natural phenomena in science, and to solve a problem or accomplish a goal in engineering. Students need both types of experiences to develop a deep and flexible understanding of how these terms are applied in each of these closely allied fields. As crosscutting concepts are encountered repeatedly across academic disciplines, familiar vocabulary can enhance engagement and understanding for English language learners, students with language processing difficulties, and students with limited literacy development.

Crosscutting concepts should not be assessed separately from practices or core ideas. Students should not be assessed on their ability to define "pattern," "system," or any other crosscutting concepts as a separate vocabulary word. To capture the vision in the Framework, students should be assessed on the extent to which they have achieved a coherent scientific worldview by recognizing similarities among core ideas in science or engineering that may at first seem very different, but are united through crosscutting concepts.

Performance expectations focus on some, but not all capabilities associated with a crosscutting concept. As core ideas grow in complexity and sophistication across the grades, it becomes more and more difficult to express them fully in performance expectations. Consequently, most performance expectations reflect only some aspects of a crosscutting concept. These aspects are indicated in the right-hand foundation box in each of the standards. All aspects of each core idea considered by the writing team can be found in the matrix at the end of this section.

Crosscutting concepts are for all students. Crosscutting concepts raise the bar for students who have not achieved at high levels in academic subjects and often are assigned to classes that emphasize "the basics," which in science may be taken to provide primarily factual information and lower order thinking skills. Consequently, it is essential that all students engage in using crosscutting concepts, which could result in leveling the playing field and promoting deeper understanding for all students.

Inclusion of Nature of Science and Engineering Concepts. Sometimes included in the crosscutting concept foundation boxes are concepts related to materials from the "Nature of Science" or "Science, Technology, Society, and the Environment." These are not to be confused with the "Crosscutting Concepts" but rather represent an organizational structure of the NGSS recognizing concepts from both the Nature of Science and Science, Technology, Society, and the Environment that extend across all of the sciences. Readers should use Appendices H and J for further information on these ideas. (NGSS Lead States, [Appendix G](), 2013, pp.1-3)

Progression of Crosscutting Concepts

Across the Grades Following is a brief summary of how each crosscutting concept increases in complexity and sophistication across the grades as envisioned in the K–12

Framework. Examples of performance expectations illustrate how these ideas play out in the NGSS.

1. ***Patterns*** "Patterns exist everywhere—in regularly occurring shapes or structures and in repeating events and relationships. For example, patterns are discernible in the symmetry of flowers and snowflakes, the cycling of the seasons, and the repeated base pairs of DNA." (p. 85) to increase (e.g., it is far more likely for a broken glass to scatter than for scattered bits to assemble themselves into a whole glass). In some cases, order seems to emerge from chaos, as when a plant sprouts, or a tornado appears amidst scattered storm clouds. It is in such examples that patterns exist and the beauty of nature is found. "Noticing patterns is often a first step to organizing phenomena and asking scientific questions about why and how the patterns occur." (p. 85)

   "Once patterns and variations have been noted, they lead to questions; scientists seek explanations for observed patterns and for the similarity and diversity within them. Engineers often look for and analyze patterns, too. For example, they may diagnose patterns of failure of a designed system under test in order to improve the design, or they may analyze patterns of daily and seasonal use of power to design a system that can meet the fluctuating needs." (pp. 85-86)

   Patterns figure prominently in the science and engineering practice of "Analyzing and Interpreting Data." Recognizing patterns is a large part of working with data. Students might look at geographical patterns on a map, plot data values on a chart or graph, or visually inspect the appearance of an organism or mineral. The crosscutting concept of patterns is also strongly associated with the practice of "Using Mathematics and Computational Thinking." It is often the case that patterns are identified best using mathematical concepts. As Richard Feynman said, "To those who do not know mathematics it is difficult to get across a real feeling as to the beauty, the deepest beauty, of nature. If you want to learn about nature, to appreciate nature, it is necessary to understand the language that she speaks in."

   The human brain is remarkably adept at identifying patterns, and students progressively build upon this innate ability throughout their school experiences. The following table lists the guidelines used by the writing team for how this progression plays out across K–12, with examples of performance expectations drawn from the NGSS (NGSS Lead States, Appendix G, 2013, pp.3-4).

2. ***Cause and Effect*** *is often the next step in science, after a discovery of patterns or events that occur together with regularity. A search for the underlying cause of a phenomenon has sparked some of the most compelling and productive scientific investigations. "Any tentative answer, or 'hypothesis,' that A causes B requires a model or mechanism for the chain of interactions that connect A and B. For example, the notion that diseases can be transmitted by a person's touch was initially treated with skepticism by the medical profession for lack of a plausible mechanism. Today infectious diseases are well understood as being transmitted by the passing of microscopic organisms (bacteria or viruses) between an infected person and another. A major activity of science is to uncover such causal connections, often with the hope that understanding the mechanisms will enable predictions and, in the case of infectious diseases, the design of preventive measures, treatments, and cures." (p. 87)*

"In engineering, the goal is to design a system to cause a desired effect, so cause-and-effect relationships are as much a part of engineering as of science. Indeed, the process of design is a good place to help students begin to think in terms of cause and effect, because they must understand the underlying causal relationships in order to devise and explain a design that can achieve a specified objective." (p.88)

When students perform the practice of "Planning and Carrying Out Investigations," they often address cause and effect. At early ages, this involves "doing" something to the system of study and then watching to see what happens. At later ages, experiments are set up to test the sensitivity of the parameters involved, and this is accomplished by making a change (cause) to a single component of a system and examining, and often quantifying, the result (effect). Cause and effect is also closely associated with the practice of "Engaging in Argument from Evidence." In scientific practice, deducing the cause of an effect is often difficult, so multiple hypotheses may coexist. For example, though the occurrence (effect) of historical mass extinctions of organisms, such as the dinosaurs, is well established, the reason or reasons for the extinctions (cause) are still debated, and scientists develop and debate their arguments based on different forms of evidence. When students engage in scientific argumentation, it is often centered about identifying the causes of an effect (NGSS Lead States, Appendix G, 2013, pp.5-6).

3. *Scale, Proportion, and Quantity are important in both science and engineering. These are fundamental assessments of dimension that form the foundation of observations about nature. Before an analysis of function or process can be made (the how or why), it is necessary to identify the what. These concepts are the starting point for scientific understanding, whether it is of a total system or its individual components. Any student who has ever played the game "Twenty Questions" understands this inherently, asking questions such as "Is it bigger than a bread box?" in order to first determine the object's size.*
   An understanding of scale involves not only understanding systems and processes vary in size, time span, and energy, but also different mechanisms operate at different scales. In engineering, "no structure could be conceived, much less constructed, without the engineer's precise sense of scale.... At a basic level, in order to identify something as bigger or smaller than something else—and how much bigger or smaller—a student must appreciate the units used to measure it and develop a feel for quantity." (p. 90)

   "The ideas of ratio and proportionality as used in science can extend and challenge students' mathematical understanding of these concepts. To appreciate the relative magnitude of some properties or processes, it may be necessary to grasp the relationships among different types of quantities—for example, speed as the ratio of distance traveled to time taken, density as a ratio of mass to volume. This use of ratio is quite different than a ratio of numbers describing fractions of a pie. Recognition of such relationships among different quantities is a key step in forming mathematical models that interpret scientific data." (p. 90)

   The crosscutting concept of Scale, Proportion, and Quantity figures prominently in the practices of "Using Mathematics and Computational Thinking" and in "Analyzing and Interpreting Data." This concept addresses taking measurements of structures and phenomena, and these fundamental observations are usually obtained, analyzed, and interpreted quantitatively. This crosscutting concept also figures prominently in the practice of "Developing and Using Models." Scale and proportion are often best

understood using models. For example, the relative scales of objects in the solar system or of the components of an atom are difficult to comprehend mathematically (because the numbers involved are either so large or so small), but visual or conceptual models make them much more understandable (e.g., if the solar system were the size of a penny, the Milky Way galaxy would be the size of Texas).
(NGSS Lead States, Appendix G, 2013, pp.6-7).

4. Systems and System Models are useful in science and engineering because the world is complex, so it is helpful to isolate a single system and construct a simplified model of it.

   "To do this, scientists and engineers imagine an artificial boundary between the system in question and everything else. They then examine the system in detail while treating the effects of things outside the boundary as either forces acting on the system or flows of matter and energy across it—for example, the gravitational force due to Earth on a book lying on a table or the carbon dioxide expelled by an organism. Consideration of flows into and out of the system is a crucial element of system design. In the laboratory or even in field research, the extent to which a system under study can be physically isolated or external conditions controlled is an important element of the design of an investigation and interpretation of results.... The properties and behavior of the whole system can be very different from those of any of its parts, and large systems may have emergent properties, such as the shape of a tree, that cannot be predicted in detail from knowledge about the components and their interactions." (p. 92)

   "Models can be valuable in predicting a system's behaviors or in diagnosing problems or failures in its functioning, regardless of what type of system is being examined.... In a simple mechanical system, interactions among the parts are describable in terms of forces among them that cause changes in motion or physical stresses. In more complex systems, it is not always possible or useful to consider interactions at this detailed mechanical level, yet it is equally important to ask what interactions are occurring (e.g., predator-prey relationships in an ecosystem) and to recognize that they all involve transfers of energy, matter, and (in some cases) information among parts of the system.... Any model of a system incorporates assumptions and approximations; the key is to be aware of what they are and how they affect the model's reliability and precision. Predictions may be reliable but not precise or, worse, precise but not reliable; the degree of reliability and precision needed depends on the use to which the model will be put." (p. 93)
   (NGSS Lead States, Appendix G, 2013, pp.7-8).

5. Energy and Matter are essential concepts in all disciplines of science and engineering, often in connection with systems. "The supply of energy and of each needed chemical element restricts a system's operation—for example, without inputs of energy (sunlight) and matter (carbon dioxide and water), a plant cannot grow. Hence, it is very informative to track the transfers of matter and energy within, into, or out of any system under study.

   "In many systems there also are cycles of various types. In some cases, the most readily observable cycling may be of matter, for example, water going back and forth between Earth's atmosphere and its surface and subsurface reservoirs. Any such cycle of matter also involves associated energy transfers at each stage, so to fully understand the water cycle, one must model not only how water moves between parts of the system but also the energy transfer mechanisms that are critical for that motion.

"Consideration of energy and matter inputs, outputs, and flows or transfers within a system or process are equally important for engineering. A major goal in design is to maximize certain types of energy output while minimizing others, in order to minimize the energy inputs needed to achieve a desired task." (p. 95)
(NGSS Lead States, Appendix G, 2013, pp.8-9).

6. Structure and Function are complementary properties. "The shape and stability of structures of natural and designed objects are related to their function(s). The functioning of natural and built systems alike depends on the shapes and relationships of certain key parts as well as on the properties of the materials from which they are made. A sense of scale is necessary in order to know what properties and what aspects of shape or material are relevant at a particular magnitude or in investigating particular phenomena—that is, the selection of an appropriate scale depends on the question being asked. For example, the substructures of molecules are not particularly important in understanding the phenomenon of pressure, but they are relevant to understanding why the ratio between temperature and pressure at constant volume is different for different substances.

   "Similarly, understanding how a bicycle works is best addressed by examining the structures and their functions at the scale of, say, the frame, wheels, and pedals. However, building a lighter bicycle may require knowledge of the properties (such as rigidity and hardness) of the materials needed for specific parts of the bicycle. In that way, the builder can seek less dense materials with appropriate properties; this pursuit may lead in turn to an examination of the atomic-scale structure of candidate materials. As a result, new parts with the desired properties, possibly made of new materials, can be designed and fabricated." (pp. 96-97)
   (NGSS Lead States, Appendix G, 2013, pp.19-10).

7. Stability and Change are the primary concerns of many, if not most scientific and engineering endeavors. "Stability denotes a condition in which some aspects of a system are unchanging, at least at the scale of observation. Stability means that a small disturbance will fade away—that is, the system will stay in, or return to, the stable condition. Such stability can take different forms, with the simplest being a static equilibrium, such as a ladder leaning on a wall. By contrast, a system with steady inflows and outflows (i.e., constant conditions) is said to be in dynamic equilibrium. For example, a dam may be at a constant level with steady quantities of water coming in and out.... A repeating pattern of cyclic change, such as the moon orbiting Earth, can also be seen as a stable situation, even though it is clearly not static.

   "An understanding of dynamic equilibrium is crucial to understanding the major issues in any complex system—for example, population dynamics in an ecosystem or the relationship between the level of atmospheric carbon dioxide and Earth's average temperature. Dynamic equilibrium is an equally important concept for understanding the physical forces in matter. Stable matter is a system of atoms in dynamic equilibrium.

"In designing systems for stable operation, the mechanisms of external controls and internal 'feedback' loops are important design elements; feedback is important to understanding natural systems as well. A feedback loop is any mechanism in which a condition triggers some action that causes a change in that same condition, such as the temperature of a room triggering the thermostatic control that turns the room's heater on or off.

"A system can be stable on a small-time scale, but on a larger time scale it may be seen to be changing. For example, when looking at a living organism over the course of an hour or a day, it may maintain stability; over longer periods, the organism grows, ages, and eventually dies. For the development of larger systems, such as the variety of living species inhabiting Earth or the formation of a galaxy, the relevant time scales may be very long indeed; such processes occur over millions or even billions of years." (pp. 99-100)
(NGSS Lead States, Appendix G, 2013, pp.10-11).

How Are the Crosscutting Concepts Connected?

Although each of the seven crosscutting concepts can be used to help students recognize deep connections between seemingly disparate topics, it can sometimes be helpful to think of how they are connected to each other. The connections can be envisioned in many different ways. The following is one way to think about their interconnections.

Patterns stand alone because patterns are a pervasive aspect of all fields of science and engineering. When first exploring a new phenomenon, children will notice similarities and differences leading to ideas for how they might be classified. The existence of patterns naturally suggests an underlying cause for the pattern. For example, observing snowflakes are all versions of six-side symmetrical shapes suggest something about how molecules pack together when water freezes; or, when repairing a device, a technician would look for a certain pattern of failures suggesting an underlying cause. Patterns are also helpful when interpreting data, which may supply valuable evidence in support of an explanation or a particular solution to a problem.

Cause and effect lie at the heart of science. Often the objective of a scientific investigation is to find the cause that underlies a phenomenon, first identified by noticing a pattern. Later, the development of theories allows for predictions of new patterns, which then provides evidence in support of the theory. For example, Galileo's observation that a ball rolling down an incline gathers speed at a constant rate eventually led to Newton's Second Law of Motion, which in turn provided predictions about regular patterns of planetary motion, and a means to guide space probes to their destinations.

Structure and function can be thought of as a special case of cause and effect. Whether the structures in question are living tissue or molecules in the atmosphere, understanding their structure is essential to making causal inferences. Engineers make such inferences when examining structures in nature as inspirations for designs to meet people's needs.

Systems and system models are used by scientists and engineers to investigate natural and designed systems. The purpose of an investigation might be to explore how the system functions, or what may be going wrong. Sometimes investigations are too dangerous or expensive to try out without first experimenting with a model.

Scale, proportion, and quantity are essential considerations when deciding how to model a phenomenon. For example, when testing a scale model of a new airplane wing in a wind tunnel, it is essential to get the proportions right and measure accurately or the results will not be valid. When using a computer simulation of an ecosystem, it is important to use informed estimates of population sizes to make reasonably accurate predictions. Mathematics is essential in both science and engineering.

Energy and matter are basic to any systems model, whether of a natural or a designed system. Systems are described in terms of matter and energy. Often, the focus of an investigation is to determine how energy or matter flows through the system or, in the case of engineering, to modify the system so a given energy input results in a more useful energy output.

Stability and change are ways of describing how a system functions. Whether studying ecosystems or engineered systems, the question is often to determine how the system is changing over time, and which factors are causing the system to become unstable. (NGSS Lead States, Appendix G, 2013, pp.11-12).

Conclusion

The purpose of this appendix is to explain the rationale behind integrating crosscutting concepts into the K–12 science curriculum and to illustrate how the seven crosscutting concepts from the Framework are integrated into the performance expectations within the NGSS. The crosscutting concepts' utility will be realized when curriculum developers and teachers develop lessons, units, and courses using the crosscutting concepts to tie together the broad diversity of science and engineering core ideas in the curriculum to realize the clear and coherent vision of the Framework (NGSS Lead States, Appendix G, 2013, pp. 12).

Resources

Cross Cutting Concepts

Website with printable K–12 Progression of CCCs:
https://static.nsta.org/ngss/MatrixOfCrosscuttingConcepts.pdf

Engineering Design in the NGSS

The following overview of Engineering Design in the NGSS was modified from The Next Generation Science Standards: For States by States, **Appendix I.** Retrieved from https://www.nextgenscience.org. (2013).

The Next Generation Science Standards (NGSS) represent a commitment to integrate 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 12th grade. There are both practical and inspirational reasons for including engineering design as an essential element of science education. Providing students with a foundation in engineering design allows them to better engage in and aspire to solve the major societal and environmental challenges they will face in the decades ahead.

Key Definitions

One of the problems of prior standards has been the lack of clear and consistent definitions of the terms science, engineering, and technology. A Framework for K–12 Science Education has defined these terms as follows:

In the K–12 context, "science" is generally taken to mean the traditional natural sciences: physics, chemistry, biology, and (more recently) earth, space, and environmental sciences…. We use the term "engineering" in a very broad sense to mean any engagement in a systematic practice of design to achieve solutions to particular human problems. Likewise, we broadly use the term "technology" to include all types of human-made systems and processes—not in the limited sense often used in schools that equates technology with modern computational and communications devices. Technologies result when engineers apply their understanding of the natural world and of human behavior to design ways to satisfy human needs and wants. (NRC 2012, pp. 11-12)

The Framework's definitions address two common misconceptions. The first is that engineering design is not just applied science. As described in Appendix F: Science and Engineering Practices in the NGSS, the practices of engineering have much in common with the practices of science, although engineering design has a different purpose and product than scientific inquiry. The second misconception is that technology describes all the ways that people have modified the natural world to meet their needs and wants. Technology does not just refer to computers or electronic devices. The purpose of defining "engineering" more broadly in the Framework and NGSS is to emphasize engineering design practices that all citizens should learn. For example, students are expected to be able to define problems — situations that people wish to change — by specifying criteria and constraints for acceptable solutions; generating and evaluating multiple solutions; building and testing prototypes; and optimizing a solution. These practices have not been explicitly included in science standards until now.

Engineering Design in the Framework. The term "engineering design" has replaced the older term "technological design," consistent with the definition of engineering as a systematic practice for solving problems, and technology as the result of that practice. According to the Framework: "From a teaching and learning point of view, it is the iterative cycle of design that offers the greatest potential for applying science knowledge in the classroom and engaging in engineering practices" (NRC 2012, pp. 201-2). The Framework recommends that students explicitly learn how to engage in engineering design practices to solve problems. The Framework also projects a vision of engineering design in the science curriculum and of what students can accomplish from early school years to high school:

A. **Defining and delimiting engineering problems** involves stating the problem to be solved as clearly as possible in terms of criteria for success, and constraints or limits.
B. **Designing solutions to engineering problems** begins with generating a number of different possible solutions, then evaluating potential solutions to see which ones best meet the criteria and constraints of the problem.
C. **Optimizing the design solution** involves a process in which solutions are systematically tested and refined and the final design is improved by trading off less important features for those that are more important.

It is important to point out that these component ideas do not always follow in order, any more than do the "steps" of scientific inquiry. At any stage, a problem-solver can redefine the problem or generate new solutions to replace an idea that just isn't working out.

Engineering Design in Relation to Student Diversity

The NGSS inclusion of engineering with science has major implications for non-dominant student groups. From a pedagogical perspective, the focus on engineering is inclusive of students who may have traditionally been marginalized in the science classroom or experienced science as not being relevant to their lives or future. By asking questions and solving meaningful problems through engineering in local contexts (e.g., watershed planning, medical equipment, instruments for communication for the Deaf), diverse students deepen their science knowledge, come to view science as relevant to their lives and future, and engage in science in socially relevant and transformative ways.

From a global perspective, engineering offers opportunities for "innovation" and "creativity" at the K–12 level. Engineering is a field that is critical to undertaking the world's challenges, and April 2013 NGSS Release Page 3 of 7 exposure to engineering activities (e.g., robotics and invention competitions) can spark interest in the study of STEM or future careers (National Science Foundation, 2010). This early engagement is particularly important for students who have traditionally not considered science as a possible career choice, including females and students from multiple languages and cultures in this global community.

Engineering Design in the NGSS

In the NGSS, engineering design is integrated throughout the document. First, a fair number of standards in the three disciplinary areas of life, physical, and Earth and space science begin with an engineering practice. In these standards, students demonstrate their understanding of science through the application of engineering practices. Second, the NGSS also include separate standards for engineering design at the K-2, 3-5, 6-8, and 9-12 grade levels. This multi-pronged approach, including engineering design both as a set of practices and as a set of core ideas, is consistent with the original intention of the Framework.

Engineering Grades K–2

Engineering design in the earliest grades introduces students to “problems” as situations that people want to change. They can use tools and materials to solve simple problems, use different representations to convey solutions, and compare different solutions to a problem and determine which is best. Students in all grade levels are not expected to come up with original solutions, although original solutions are always welcome. Emphasis is on thinking through the needs or goals that need to be met and which solutions best meet those needs and goals Framework (NGSS Lead States, Appendix I , 2013, pp. 1-3).

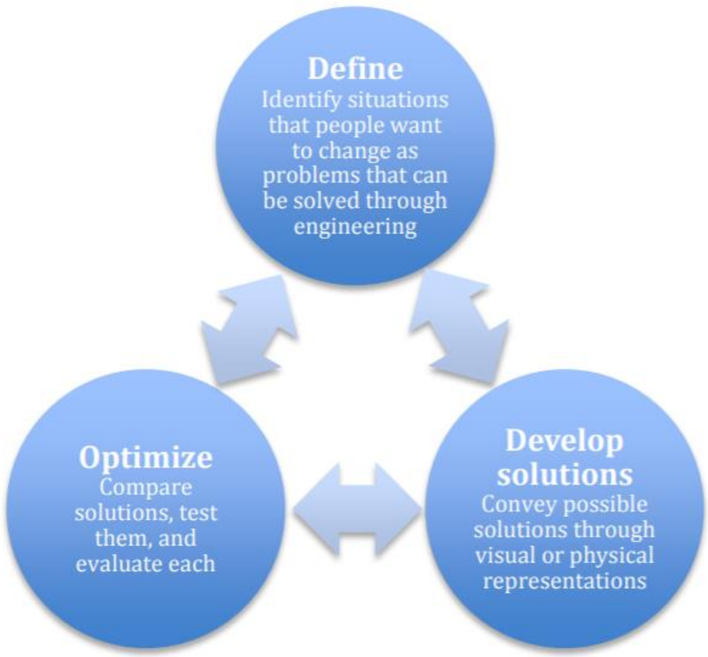


Image source: Appendix I (2013)

Engineering Grades 3–5

At the upper elementary grades, engineering design engages students in more formalized problem solving. Students define a problem using criteria for success and constraints or limits of possible solutions. Students research and consider multiple possible solutions to a given problem. Generating and testing solutions also becomes more rigorous as the students learn to optimize solutions by revising them several times to obtain the best possible design (NGSS Lead States, Appendix I , 2013, p. 4).

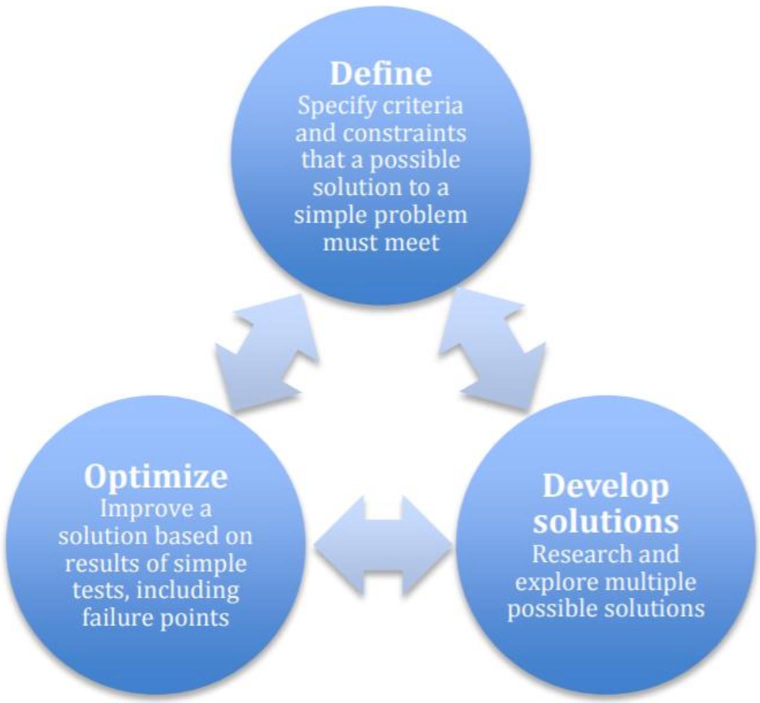


Image source: Appendix I (2013)

Engineering Grades 6–8

At the middle school level, students learn to sharpen the focus of problems by precisely specifying criteria and constraints of successful solutions, taking into account not only what needs the problem is intended to meet, but also the larger context within which the problem is defined, including limits to possible solutions. Students can identify elements of different solutions and combine them to create new solutions. Students at this level are expected to use systematic methods to compare different solutions to see which best meet criteria and constraints, and to test and revise solutions a number of times in order to arrive at an optimal design (NGSS Lead States, Appendix I , 2013, pp. 4-5).

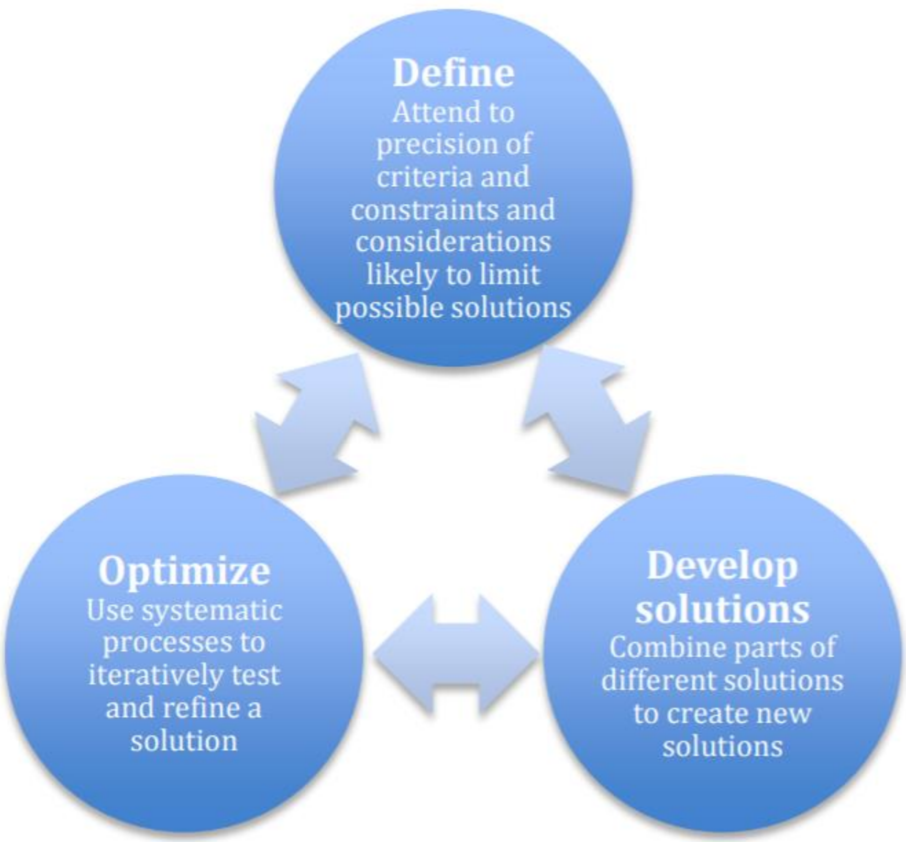


Image source: Appendix I (2013)

Engineering Grades 9–12

Engineering design at the high school level engages students in complex problems that include issues of social and global significance. Such problems need to be broken down into simpler problems to be tackled one at a time. Students are also expected to quantify criteria and constraints so that it will be possible to use quantitative methods to compare the potential of different solutions. While creativity in solving problems is valued, emphasis is on identifying the best solution to a problem, which often involves researching how others have solved it before. Students are expected to use mathematics and/or computer simulations to test solutions under different conditions, prioritize criteria, consider trade-offs, and assess social and environmental impacts (NGSS Lead States, Appendix I , 2013, pp. 5-6).

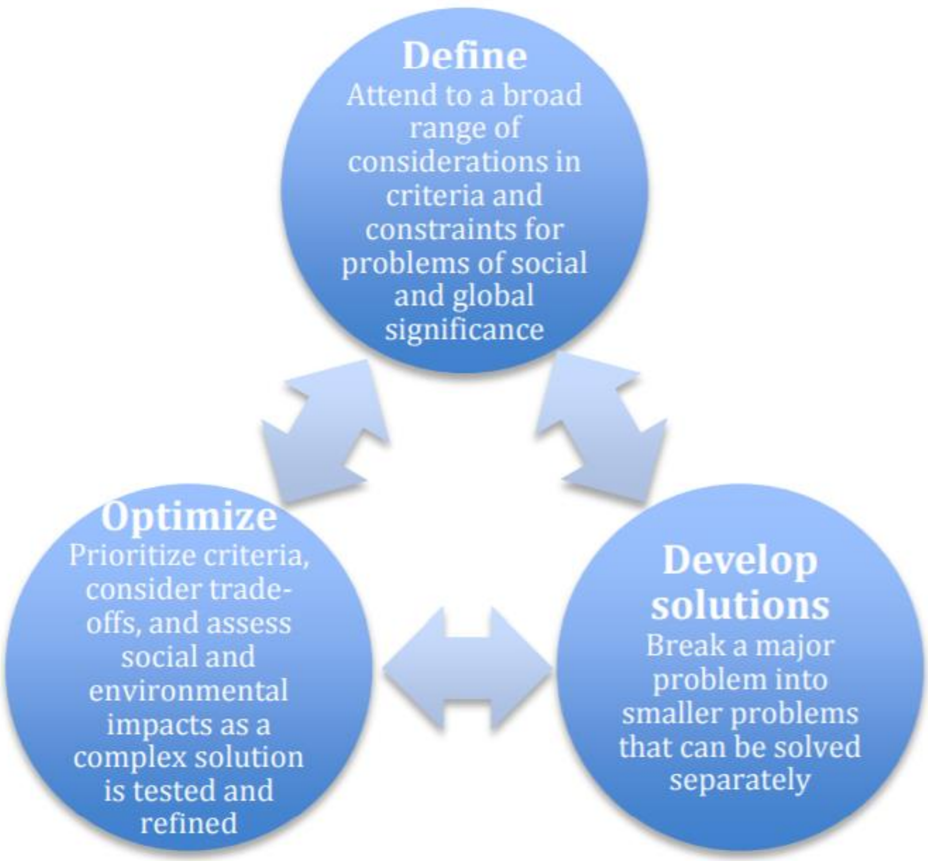


Image source: Appendix I (2013)

Conclusion

The inclusion of engineering design within the fabric of the NGSS has profound implications for curriculum, teaching, and assessment. All students need opportunities to acquire engineering design practices and concepts alongside the practices and concepts of science. The decision to integrate engineering design into the science disciplines is not intended either to encourage or discourage development of engineering courses.

In recent years, many middle and high schools have introduced engineering courses that build students' engineering skill, engage them in experiences using a variety of technologies, and provide information on a range of engineering careers. The engineering design standards included in the NGSS could certainly be a component of such courses, but most likely do not represent the full scope of such courses or an engineering pathway. Rather, the purpose of the NGSS is to emphasize the key knowledge and skills that all students need in order to engage fully as workers, consumers, and citizens in 21st century society (NGSS Lead States, Appendix I , 2013, p.6)

Grade Level Standards

Disciplinary Core Idea Progressions

The Framework describes the progression of disciplinary core ideas in the grade band endpoints. The progressions are summarized in Appendix E (2013), which describe the content that occurs at each grade band. Some of the sub-ideas within the disciplinary core ideas overlap significantly. Readers will notice there is not always a clear division between those ideas, so several progressions are divided among more than one sub-idea. The purpose of these diagrams is to briefly describe the content at each grade band for each disciplinary core idea across K–12. This progression example matrix below is for reference only. The full progressions can be seen in the Framework. In addition, the NGSS show the integration of the three dimensions. This document in no way endorses separating the disciplinary core ideas from the other two dimensions (NGSS Lead States, Appendix E, 2013, p.1).

Printable Disciplinary Core Ideas progressions for each science domain and topic
K-12 Progression of DCIs https://static.nsta.org/ngss/20130509/AppendixE-DCIProgressionsWithinNGSS_1.pdf

Kindergarten Standards Overview:
(www.nextgenscience.org/sites/default/files/K-2Topic.pdf)

The performance expectations in kindergarten help students formulate answers to questions such as: “What happens if you push or pull an object harder? Where do animals live and why do they live there? What is the weather like today and how is it different from yesterday?” Kindergarten performance expectations include PS2, PS3, LS1, ESS2, ESS3, and ETS1 Disciplinary Core Ideas from the NRC Framework. Students are expected to develop understanding of patterns and variations in local weather and the purpose of weather forecasting to prepare for, and respond to, severe weather. Students are able to apply an understanding of the effects of different strengths or different directions of pushes and pulls on the motion of an object to analyze a design solution. Students are also expected to develop understanding of what plants and animals (including humans) need to survive and the relationship between their needs and where they live. The crosscutting concepts of patterns; cause and effect; systems and system models; interdependence of science, engineering, and technology; and influence of engineering, technology, and science on society and the natural world are called out as organizing concepts for these disciplinary core ideas.

In the kindergarten performance expectations, students are expected to demonstrate grade-appropriate proficiency in asking questions, developing and using models, planning and carrying out investigations, analyzing and interpreting data, designing solutions, engaging in argument from evidence, and obtaining, evaluating, and communicating information. Students are expected to use these practices to demonstrate understanding of the core ideas (NGSS Lead States, Grades K-2 By Topic, 2013, p.2).

Kindergarten: https://ngss.nsta.org/AccessStandardsByTopic.aspx

	Life Science	Earth & Space Science	Physical Science
K	K-LS1 From Molecules to Organisms: Structures and Processes	K-ESS2 Earth's Systems	K-PS2 Motion and Stability: Forces and Interactions
		K-ESS3 Earth and Human Activity	K-PS3 Energy
	K-2-ETS1 Engineering Design		

Grade 1 Standards Overview: (https://www.nextgenscience.org/sites/default/files/K-2Topic.pdf)

The performance expectations in first grade help students formulate answers to questions such as: "What happens when materials vibrate? What happens when there is no light? What are some ways plants and animals meet their needs so that they can survive and grow? How are parents and their children similar and different? What objects are in the sky and how do they seem to move?" First grade performance expectations include PS4, LS1, LS3, and ESS1 Disciplinary Core Ideas from the NRC Framework.

Students are expected to develop understanding of the relationship between sound and vibrating materials as well as between the availability of light and ability to see objects. The idea that light travels from place to place can be understood by students at this level through determining the effect of placing objects made with different materials in the path of a beam of light. Students are also expected to develop understanding of how plants and animals use their external parts to help them survive, grow, and meet their needs as well as how behaviors of parents and offspring help the offspring survive. The understanding is developed that young plants and animals are like, but not exactly the same as, their parents. Students are able to observe, describe, and predict some patterns of the movement of objects in the sky. The crosscutting concepts of patterns; cause and effect; structure and function; and influence of engineering, technology, and science on society and the natural world are called out as organizing concepts for these disciplinary core ideas.

In the first-grade performance expectations, students are expected to demonstrate grade-appropriate proficiency in planning and carrying out investigations, analyzing and interpreting data, constructing explanations and designing solutions, and obtaining, evaluating, and communicating information. Students are expected to use these practices to demonstrate understanding of the core ideas (NGSS Lead States, Grades K-2 By Topic, 2013, p.6).

Grade 1 Standards: https://ngss.nsta.org/AccessStandardsByTopic.aspx

	Life Science	Earth & Space Science	Physical Science
1	1-LS1 From Molecules to Organisms: Structures and Processes	1-ESS1 Earth's Place in the Universe	1-PS4 Waves and Their Applications in Technologies for Information Transfer
	1-LS3 Heredity: Inheritance and Variation of Traits		
	K-2-ETS1 Engineering Design		

Grade 2 Standards Overview: (https://www.nextgenscience.org/sites/default/files/K-2Topic.pdf)

The performance expectations in second grade help students formulate answers to questions such as: "How does land change and what are some things that cause it to change? What are the different kinds of land and bodies of water? How are materials similar and different from one another, and how do the properties of the materials relate to their use? What do plants need to grow? How many types of living things live in a place?" Second grade performance expectations include PS1, LS2, LS4, ESS1, ESS2, and ETS1 Disciplinary Core Ideas from the NRC Framework.
Students are expected to develop an understanding of what plants need to grow and how plants depend on animals for seed dispersal and pollination. Students are also expected to compare the diversity of life in different habitats. An understanding of observable properties of materials is developed by students at this level through analysis and classification of different materials.

Students are able to apply their understanding of the idea that wind and water can change the shape of the land to compare design solutions to slow or prevent such change. Students are able to use information and models to identify and represent the shapes and kinds of land and bodies of water in an area and where water is found on Earth. The crosscutting concepts of patterns; cause and effect; energy and matter; structure and function; stability and change; and influence of engineering, technology, and science on society and the natural world are called out as organizing concepts for these disciplinary core ideas.

In the second-grade performance expectations, students are expected to demonstrate grade appropriate proficiency in developing and using models, planning and carrying out investigations, analyzing and interpreting data, constructing explanations and designing solutions, engaging in argument from evidence, and obtaining, evaluating, and communicating information. Students are expected to use these practices to demonstrate understanding of the core ideas (NGSS Lead States, Grades K-2 By Topic, 2013, p.10).

Grade 2 Standards: https://ngss.nsta.org/AccessStandardsByTopic.aspx

	Life Science	Earth & Space Science	Physical Science
2	2-LS2 Ecosystems: Interactions, Energy, and Dynamics	2-ESS1 Earth's Place in the Universe	2-PS1 Matter and Its Interactions
	2-LS4 Biological Evolution: Unity and Diversity	2-ESS2 Earth's Systems	
	K-2-ETS1 Engineering Design		

Grade 3 Standards Overview: (https://www.nextgenscience.org/sites/default/files/3-5Topic.pdf)

The performance expectations in third grade help students formulate answers to questions such as: "What is typical weather in different parts of the world and during different times of the year? How can the impact of weather-related hazards be reduced? How do organisms vary in their traits? How are plants, animals, and environments of the past similar or different from current plants, animals, and environments? What happens to organisms when their environment changes? How do equal and unequal forces on an object affect the object? How can magnets be used?" Third grade performance expectations include PS2, LS1, LS2, LS3, LS4, ESS2, and ESS3 Disciplinary Core Ideas from the NRC Framework.

Students are able to organize and use data to describe typical weather conditions expected during a particular season. By applying their understanding of weather-related hazards, students are able to make a claim about the merit of a design solution that reduces the impacts of such hazards. Students are expected to develop an understanding of the similarities and differences of organisms' life cycles. An understanding that organisms have different inherited traits and that the environment can also affect the traits that an organism develops, is acquired by students at this level. In addition, students are able to construct an explanation using evidence for how the variations in characteristics among individuals of the same species may provide advantages in surviving, finding mates, and reproducing. Students are expected to develop an understanding of types of organisms that lived long ago and also about the nature of their environments. Third graders are expected to develop an understanding of the idea that when the environment changes some organisms survive and reproduce, some move to new locations, some move into the transformed environment, and some die. Students are able to determine the effects of balanced and unbalanced forces on the motion of an object and the cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other. They are then able to apply their understanding of magnetic interactions to define a simple design problem that can be solved with magnets. The crosscutting concepts of patterns; cause and effect; scale, proportion, and quantity; systems and system models; interdependence of science, engineering, and technology; and influence of engineering, technology, and science on society and the natural world are called out as organizing concepts for these disciplinary core ideas.

In the third-grade performance expectations, students are expected to demonstrate grade-appropriate proficiency in asking questions and defining problems; developing and using models, planning and carrying out investigations, analyzing and interpreting data, constructing explanations and designing solutions, engaging in argument from evidence, and obtaining, evaluating, and communicating information. Students are expected to use these practices to demonstrate understanding of the core ideas (NGSS Lead States, Grades 3-5 By Topic, 2013, p.1).

Grade 3 Standards: https://ngss.nsta.org/AccessStandardsByTopic.aspx

	Life Science	Earth & Space Science	Physical Science
3	3-LS1 From Molecules to Organisms: Structures and Processes	3-ESS2 Earth's Systems	3-PS2 Motion and Stability: Forces and Interactions
	3-LS2 Ecosystems: Interactions, Energy, and Dynamics		
	3-LS3 Heredity: Inheritance and Variation of Traits	3-ESS3 Earth and Human Activity	
	3-LS4 Biological Evolution: Unity and Diversity		
	3-5-ETS1 Engineering Design		

Grade 4 Standards Overview: (https://www.nextgenscience.org/sites/default/files/3-5Topic.pdf)

The performance expectations in fourth grade help students formulate answers to questions such as: "What are waves and what are some things they can do? How can water, ice, wind and vegetation change the land? What patterns of Earth's features can be determined with the use of maps? How do internal and external structures support the survival, growth, behavior, and reproduction of plants and animals? What is energy and how is it related to motion? How is energy transferred? How can energy be used to solve a problem?" Fourth grade performance expectations include PS3, PS4, LS1, ESS1, ESS2, ESS3, and ETS1 Disciplinary Core Ideas from the NRC Framework.

Students are able to use a model of waves to describe patterns of waves in terms of amplitude and wavelength, and that waves can cause objects to move. Students are expected to develop understanding of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation. They apply their knowledge of natural Earth processes to generate and compare multiple solutions to reduce the impacts of such processes on humans. In order to describe patterns of Earth's features, students analyze and interpret data from maps. Fourth graders are expected to develop an understanding that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction. By developing a model, they describe that an object can be seen when light reflected from its surface enters the eye. Students are able to use evidence to construct an explanation of the relationship between the speed of an object and the energy of that object. Students are expected to develop an understanding that energy can be transferred from place to place by sound, light, heat, and electric currents or from object to object through collisions. They apply their understanding of energy to design, test, and refine a device that converts energy from one form to another. The crosscutting concepts of patterns; cause and effect; energy and matter; systems and system models; interdependence of science, engineering, and technology; and influence of engineering, technology, and science on society and the natural world are called out as organizing concepts for these disciplinary core ideas.

In the fourth-grade performance expectations, students are expected to demonstrate grade-appropriate proficiency in asking questions, developing and using models, planning and carrying out investigations, analyzing and interpreting data, constructing explanations and designing solutions, engaging in argument from evidence, and obtaining, evaluating, and communicating information. Students are expected to use these practices to demonstrate understanding of the core ideas (NGSS Lead States, Grades 3-5 By Topic, 2013, p.6).

Grade 4 Standards: https://ngss.nsta.org/AccessStandardsByTopic.aspx

	Life Science	Earth & Space Science	Physical Science
4	4-LS1 From Molecules to Organisms: Structures and Processes	4-ESS1 Earth's Place in the Universe	4-PS3 Energy
		4-ESS2 Earth's Systems	4-PS4 Waves and Their Applications in Technologies for Information Transfer
		4-ESS3 Earth and Human Activity	
	3-5-ETS1 Engineering Design		

Grade 5 Standards Overview: (https://www.nextgenscience.org/sites/default/files/3-5Topic.pdf)

The performance expectations in fifth grade help students formulate answers to questions such as: "When matter changes, does its weight change? How much water can be found in different places on Earth? Can new substances be created by combining other substances? How does matter cycle through ecosystems? Where does the energy in food come from and what is it used for? How do lengths and directions of shadows or relative lengths of day and night change from day to day, and how does the appearance of some stars change in different seasons?" Fifth grade performance expectations include PS1, PS2, PS3, LS1, LS2, ESS1, ESS2, and ESS3 Disciplinary Core Ideas from the NRC Framework. Students are able to describe that matter is made of particles too small to be seen through the development of a model. Students develop an understanding of the idea that regardless of the type of change that matter undergoes, the total weight of matter is conserved. Students determine whether the mixing of two or more substances results in new substances. Through the development of a model using an example, students are able to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact. They describe and graph data to provide evidence about the distribution of water on Earth. Students develop an understanding of the idea that plants get the materials they need for growth chiefly from air and water. Using models, students can describe the movement of matter among plants, animals, decomposers, and the environment and that energy in animals' food was once energy from the sun. Students are expected to develop an understanding of patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky. The crosscutting concepts of patterns; cause and effect; scale, proportion, and quantity; energy and matter; and systems and systems models are called out as organizing concepts for these disciplinary core ideas. In the fifth-grade performance expectations, students are expected to demonstrate grade-appropriate proficiency in developing and using models, planning and carrying out investigations, analyzing and interpreting data, using mathematics and computational thinking, engaging in argument from evidence, and obtaining, evaluating, and communicating information; and to use these practices to demonstrate understanding of the core ideas (NGSS Lead States, Grades 3-5 By Topic, 2013, p.11).

Grade 5 Standards: https://ngss.nsta.org/AccessStandardsByTopic.aspx

	Life Science	Earth & Space Science	Physical Science
5	5-LS1 From Molecules to Organisms: Structures and Processes	5-ESS1 Earth's Place in the Universe	5-PS1 Matter and Its Interactions
	5-LS2 Ecosystems: Interactions, Energy, and Dynamics	5-ESS2 Earth's Systems	5-PS2 Motion and Stability: Forces and Interactions
		5-ESS3 Earth and Human Activity	5-PS3 Energy
	3-5-ETS1 Engineering Design		

Middle School Grades 6-8 Standards Overview: (https://www.nextgenscience.org/sites/default/files/MSTopic.pdf)

Students in middle school continue to develop understanding of four core ideas in the physical sciences. The middle school performance expectations in the Physical Sciences build on the K – 5 ideas and capabilities to allow learners to explain phenomena central to the physical sciences but also to the life sciences and earth and space science. The performance expectations in physical science blend the core ideas with scientific and engineering practices and crosscutting concepts to support students in developing useable knowledge to explain real world phenomena in the physical, biological, and earth and space sciences. In the physical sciences, performance expectations at the middle school level focus on students developing understanding of several scientific practices. These include developing and using models, planning and conducting investigations, analyzing and interpreting data, using mathematical and computational thinking, and constructing explanations; and to use these practices to demonstrate understanding of the core ideas. Students are also expected to demonstrate understanding of several of engineering practices including design and evaluation.

The performance expectations in the topic **Structure and Properties of Matter** help students to formulate an answer to the questions: "How can particles combine to produce a substance with different properties? How does thermal energy affect particles?" by building understanding of what occurs at the atomic and molecular scale. By the end of middle school, students will be able to apply understanding that pure substances have characteristic properties and are made from a single type of atom or molecule. They will be able to provide molecular level accounts to explain states of matters and changes between states. The crosscutting concepts of cause and effect; scale, proportion and quantity; structure and function; interdependence of science, engineering, and technology; and influence of science, engineering and technology on society and the natural world are called out as organizing concepts for these disciplinary core ideas. In these performance expectations, students are expected to demonstrate proficiency in developing and using models, and obtaining, evaluating, and communicating information. Students use these scientific and engineering practices to demonstrate understanding of the core ideas.

The performance expectations in the topic **Chemical Reactions** help students to formulate an answer to the questions: “What happens when new materials are formed? What stays the same and what changes?” by building understanding of what occurs at the atomic and molecular scale during chemical reactions. By the end of middle school, students will be able to provide molecular level accounts to explain that chemical reactions involve regrouping of atoms to form new substances, and that atoms rearrange during chemical reactions. Students are also able to apply an understanding of the design and the process of optimization in engineering to chemical reaction systems. The crosscutting concepts of patterns and energy and matter are called out as organizing concepts for these disciplinary core ideas. In these performance expectations, students are expected to demonstrate proficiency in developing and using models, analyzing and interpreting data, and designing solutions. Students use these scientific and engineering practices to demonstrate understanding of the core ideas.

The performance expectations in the topic **Forces and Interactions** focus on helping students understand ideas related to why some objects will keep moving, why objects fall to the ground and why some materials are attracted to each other while others are not. Students answer the question, “How can one describe physical interactions between objects and within systems of objects?” At the middle school level, the PS2 Disciplinary Core Idea from the NRC Framework is broken down into two sub-ideas: Forces and Motion and Types of interactions. By the end of middle school, students will be able to apply Newton’s Third Law of Motion to relate forces to explain the motion of objects. Students also apply ideas about gravitational, electrical, and magnetic forces to explain a variety of phenomena including beginning ideas about why some materials attract each other while other repel. In particular, students will develop understanding that gravitational interactions are always attractive, but that electrical and magnetic forces can be both attractive and negative. Students also develop ideas that objects can exert forces on each other even though the objects are not in contact, through fields. Students are also able to apply an engineering practice and concept to solve a problem caused when objects collide. The crosscutting concepts of cause and effect; system and system models; stability and change; and the influence of science, engineering, and technology on society and the natural world serve as organizing concepts for these disciplinary core ideas. In these performance expectations, students are expected to demonstrate proficiency in asking questions, planning and carrying out investigations, and designing solutions, and engaging in argument; and to use these practices to demonstrate understanding of the core ideas.

The performance expectations in the topic **Energy** help students formulate an answer to the question, “How can energy be transferred from one object or system to another?” At the middle school level, the PS3 Disciplinary Core Idea from the NRC Framework is broken down into four sub-core ideas: Definitions of Energy, Conservation of Energy and Energy Transfer, the Relationship between Energy and Forces, and Energy in Chemical Process and Everyday Life. Students develop their understanding of important qualitative ideas about energy including that the interactions of objects can be explained and predicted using the concept of transfer of energy from one object or system of objects to another, and that the total change of energy in any system is always equal to the total energy transferred into or out of the system. Students understand that objects that are moving have kinetic energy and that objects may also contain stored (potential) energy, depending on their relative positions. Students will also come to know the difference between energy and temperature, and begin to develop an understanding of the relationship between force and energy. Students are also able to apply an understanding of design to the process of energy transfer. The crosscutting concepts of scale, proportion, and quantity; systems and system models; and energy are called out as organizing concepts for these disciplinary core ideas. These performance expectations expect students to demonstrate proficiency in developing and using models, planning investigations, analyzing and interpreting data, and designing solutions, and engaging in argument from evidence and to use these practices to demonstrate understanding of the core ideas in PS3.

The performance expectations in the topic **Waves and Electromagnetic Radiation** help students formulate an answer to the question, "What are the characteristic properties of waves and how can they be used?" At the middle school level, the PS4 Disciplinary Core Idea from the NRC Framework is broken down into Wave Properties, Electromagnetic Radiation, and Information Technologies and Instrumentation. Students are able to describe and predict characteristic properties and behaviors of waves when the waves interact with matter. Students can apply an understanding of waves as a means to send digital information. The crosscutting concepts of patterns and structure and function are used as organizing concepts for these disciplinary core ideas. These performance expectations focus on students demonstrating proficiency in developing and using models; using mathematical thinking; and obtaining, evaluating and communicating information; and to use these practices to demonstrate understanding of the core ideas (NGSS Lead States, Middle School By Topic, 2013, pp.1-2).

Middle School Grades 6-8 Standards: https://ngss.nsta.org/AccessStandardsByTopic.aspx

Life Science	Earth & Space Science	Physical Science
MS-LS1 From Molecules to Organisms: Structures and Processes	MS-ESS1 Earth's Place in the Universe	MS-PS1 Matter and its Interactions
MS-LS2 Ecosystems: Interactions, Energy, and Dynamics	MS-ESS2 Earth's Systems	MS-PS2 Motion and Stability: Forces and Interactions
MS-LS3 Heredity: Inheritance and Variation of Traits	MS-ESS3 Earth and Human Activity	MS-PS3 Energy
MS-LS4 Biological Evolution: Unity and Diversity		MS-PS4 Waves and their Applications in Technologies for Information Transfer
MS-ETS1 Engineering Design		

High School Grades 9-12 Standards Overview: (https://www.nextgenscience.org/sites/default/files/HSTopic.pdf)

Students in high school continue to develop their understanding of the four core ideas in the physical sciences. These ideas include the most fundamental concepts from chemistry and physics, but are intended to leave room for expanded study in upper-level high school courses. The high school performance expectations in Physical Science build on the middle school ideas and skills and allow high school students to explain more in-depth phenomena central not only to the physical sciences, but to life and earth and space sciences as well. These performance expectations blend the core ideas with scientific and engineering practices and crosscutting concepts to support students in developing useable knowledge to explain ideas across the science disciplines. In the physical science performance expectations at the high school level, there is a focus on several scientific practices. These include developing and using models, planning and conducting investigations, analyzing and interpreting data, using mathematical and computational thinking, and constructing explanations; and to use these practices to demonstrate understanding of the core ideas. Students are also expected to demonstrate understanding of several engineering practices, including design and evaluation.

The performance expectations in the topic **Structure and Properties of Matter** help students formulate an answer to the question, “How can one explain the structure and properties of matter?” Two sub-ideas from the NRC Framework are addressed in these performance expectations: the structure and properties of matter, and nuclear processes. Students are expected to develop understanding of the substructure of atoms and provide more mechanistic explanations of the properties of substances. Students are able to use the periodic table as a tool to explain and predict the properties of elements. Phenomena involving nuclei are also important to understand, as they explain the formation and abundance of the elements, radioactivity, the release of energy from the sun and other stars, and the generation of nuclear power. The crosscutting concepts of patterns, energy and matter, and structure and function are called out as organizing concepts for these disciplinary core ideas. In these performance expectations, students are expected to demonstrate proficiency in developing and using models, planning and conducting investigations, and communicating scientific and technical information; and to use these practices to demonstrate understanding of the core ideas.

The performance expectations in the topic **Chemical Reactions** help students formulate an answer to the questions: “How do substances combine or change (react) to make new substances? How does one characterize and explain these reactions and make predictions about them?” Chemical reactions, including rates of reactions and energy changes, can be understood by students at this level in terms of the collisions of molecules and the rearrangements of atoms. Using this expanded knowledge of chemical reactions, students are able to explain important biological and geophysical phenomena. Students are also able to apply an understanding of the process of optimization in engineering design to chemical reaction systems. The crosscutting concepts of patterns, energy and matter, and stability and change are called out as organizing concepts for these disciplinary core ideas. In these performance expectations, students are expected to demonstrate proficiency in developing and using models, using mathematical thinking, constructing explanations, and designing solutions; and to use these practices to demonstrate understanding of the core ideas.

The Performance Expectations associated with the topic **Forces and Interactions** supports students’ understanding of ideas related to why some objects will keep moving, why objects fall to the ground, and why some materials are attracted to each other while others are not. Students should be able to answer the question, “How can one explain and predict interactions between objects and within systems of objects?” The disciplinary core idea expressed in the Framework for PS2 is broken down into the sub ideas of Forces and

Motion and Types of Interactions. The performance expectations in PS2 focus on students building understanding of forces and interactions and Newton's Second Law. Students also develop understanding that the total momentum of a system of objects is conserved when there is no net force on the system. Students are able to use Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects. Students are able to apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision. The crosscutting concepts of patterns, cause and effect, and systems and system models are called out as organizing concepts for these disciplinary core ideas. In the PS2 performance expectations, students are expected to demonstrate proficiency in planning and conducting investigations, analyzing data and using math to support claims, and applying scientific ideas to solve design problems; and to use these practices to demonstrate understanding of the core ideas.

The Performance Expectations associated with the topic **Energy** help students formulate an answer to the question, "How is energy transferred and conserved?" The disciplinary core idea expressed in the Framework for PS3 is broken down into four sub-core ideas: Definitions of Energy, Conservation of Energy and Energy Transfer, the Relationship between Energy and Forces, and Energy in Chemical Process and Everyday Life. Energy is understood as quantitative property of a system that depends on the motion and interactions of matter and radiation within that system, and the total change of energy in any system is always equal to the total energy transferred into or out of the system. Students develop an understanding that energy at both the macroscopic and the atomic scale can be accounted for as either motions of particles or energy associated with the configuration (relative positions) of particles. In some cases, the energy associated with the configuration of particles can be thought of as stored in fields. Students also demonstrate their understanding of engineering principles when they design, build, and refine devices associated with the conversion of energy. The crosscutting concepts of cause and effect; systems and system models; energy and matter; and the influence of science, engineering, and technology on society and the natural world are further developed in the performance expectations associated with PS3. In these performance expectations, students are expected to demonstrate proficiency in developing and using models, planning and carrying out investigations, using computational thinking, and designing solutions; and to use these practices to demonstrate understanding of the core ideas.

The Performance Expectations associated with the topic **Waves and Electromagnetic Radiation** are critical to understand how many new technologies work. As such, this disciplinary core idea helps students answer the question, "How are waves used to transfer energy and send and store information?" The disciplinary core idea in PS4 is broken down into Wave Properties, Electromagnetic Radiation, and Information Technologies and Instrumentation. Students are able to apply understanding of how wave properties and the interactions of electromagnetic radiation with matter can transfer information across long distances, store information, and investigate nature on many scales. Models of electromagnetic radiation as either a wave of changing electric and magnetic fields or as particles are developed and used. Students understand that combining waves of different frequencies can make a wide variety of patterns and thereby encode and transmit information. Students also demonstrate their understanding of engineering ideas by presenting information about how technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy. The crosscutting concepts of cause and effect; systems and system models; stability and change; interdependence of science, engineering, and technology; and the influence of engineering, technology, and science on society and the natural world are highlighted as organizing concepts for these disciplinary core ideas. In the PS3 performance expectations, students are expected to demonstrate proficiency in asking questions, using mathematical thinking, engaging in argument from evidence, and obtaining, evaluating and communicating information; and to use these practices to demonstrate understanding of the core ideas (NGSS Lead States, High School By Topic, 2013, pp. 1-3).

High School Grades 9-12 Standards: **https://ngss.nsta.org/AccessStandardsByTopic.aspx**

Life Science	Earth & Space Science	Physical Science
HS-LS1 From Molecules to Organisms: Structures and Processes	HS-ESS1 Earth's Place in the Universe	HS-PS1 Matter and its Interactions
HS-LS2 Ecosystems: Interactions, Energy, and Dynamics	HS-ESS2 Earth's Systems	HS-PS2 Motion and Stability: Forces and Interactions
HS-LS3 Heredity: Inheritance and Variation of Traits	HS-ESS3 Earth and Human Activity	HS-PS3 Energy
HS-LS4 Biological Evolution: Unity and Diversity		HS-PS4 Waves and their Applications in Technologies for Information Transfer
HS-ETS1 Engineering Design		

WIDA ELD Standards for MLLs

For educators with one or more active multilingual learners (MLLs) on their roster, enacting standards-aligned instruction means working with both state-adopted content standards and state-adopted English language development (ELD) standards. Under ESSA, all educators are required to reflect on the language demands of their grade-level content and move MLLs toward both English language proficiency and academic content proficiency. In other words, every Rhode Island educator shares responsibility for promoting disciplinary language development through content instruction.

Fortunately, the five WIDA ELD Standards lend themselves to integration in the core content areas. Standard 1 is cross-cutting and applicable in every school context, whereas Standards 2–5 focus on language use in each of the content areas. Standard 2 is dedicated to the language for language arts. Educators of English language arts are thus expected to support Standard 1 and Standard 2 as part of their core classroom instruction.

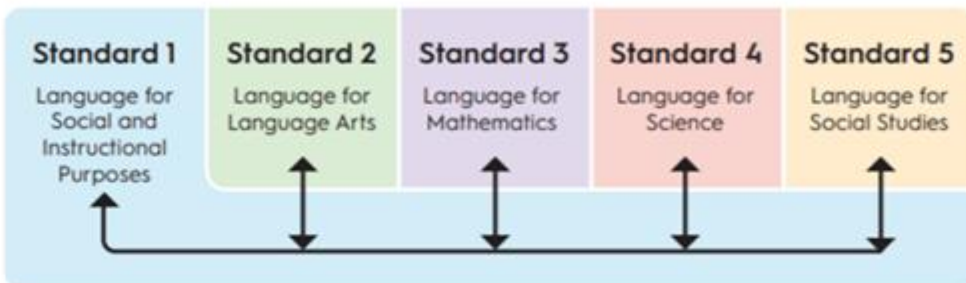


Image Source: [2020 Edition of WIDA ELD Standards Framework]

Each of the WIDA ELD Standards is broken into four genre families: *Narrate*, *Inform*, *Explain*, and *Argue*. WIDA refers to these genre families as **Key Language Uses** (KLUs) and generated them based on an analysis of the language demands placed on students by the academic content standards. The KLUs are important because they drive explicit language instruction in each of the content areas. For Standards 2–5, the distribution of KLUs is similar across grades 4–12, but this distribution varies in the early grades, with grades K–3 placing more emphasis on *Inform* than *Explain* or *Argue*. Of the four content areas, only English language arts features *Narrate* as very prominent.

Each KLU is further broken down by language function and feature. **Language functions** reflect the dominant practices for engaging in genre-specific tasks (e.g., students often orient audiences in narratives for ELA by describing the setting or characters). By contrast, the **language features** represent a sampling of linguistic and non-linguistic resources (e.g., connected clauses, noun phrases, tables, graphs) that students might use when performing a particular language function. Together, the KLUs, language functions, and language features capture what it would look and sound like for students to use language deftly in language arts. Please see below for an example of how these three elements appear in the WIDA ELD Standards.

GRADES 4-5 **WIDA ELD STANDARD 4** Language for Science **Explain**

Language Expectations: Multilingual learners will...

ELD-SC.4-5.Explain.Interpretive
Interpret scientific explanations by

- Defining investigable questions or design problems based on observations, data, and prior knowledge about a phenomenon
- Obtaining and combining evidence and information to help explain how or why a phenomenon occurs
- Identifying evidence that supports particular points in an explanation

ELD-SC.4-5.Explain.Expressive
Construct scientific explanations that

- Describe observations and/or data about a phenomenon
- Establish neutral or objective stance in communicating results
- Develop reasoning to show relationships between evidence and claims
- Summarize and/or compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution

Language Functions and Sample Language Features

Describe observations and/or evidence about a phenomenon through...

- Abstract nouns to introduce concepts, ideas, and technical terms *(cycles, states of matter, condensation)*
- Cohesion to reference ideas, people across text *(pronouns, renaming subject, synonyms)*
- Relating verbs to state relationships or attributes *(have, be, belong to)*
- Timeless verbs to state on-going facts about the phenomenon *(ocean water evaporates)*

Establish neutral or objective stance in communicating results through...

- Passive voice and declarative statements *(evaporation is caused by, ice and snow evaporate)*
- Word choices to moderate stance, e.g., hedging *(could/might, sometimes, usually)*
- Objective language to adjust precision and/or invite shared interest

Image Source: [2020 Edition of WIDA ELD Standards Framework]

The 2020 Edition of the WIDA ELD Standards Framework contains other resources, such as annotated language samples, that can support educators in promoting integrated language development in science. The annotated language samples show the language functions and language features in action with grade-level texts, as shown in the example below for the KLU *Explain* in grade 1, science. It offers insights into how educators might unpack the language of their discipline for the KLU *Explain* in grade 1 science.

GRADE 1

WIDA ELD STANDARD 4 Language for Science

Explain

Annotated Language Sample

Context: This text was written by first grade teacher modeling the writing of sequential explanations about observed phenomena. Together, the class deconstructed the text, examined its language and stages, and then jointly constructed a similar text about the life cycle of a butterfly.

Language Expectation ELD-SC.1.Explain.Expressive
Multilingual learners use language to construct scientific explanations that
- Describe observations and/or data about a phenomenon
- Relate how a series of events causes something to happen
- Compare multiple solutions to a problem

Functions & Features	The Life Cycle of a Frog	Functions & Features
Describe observations and/ or data about a phenomenon through… Cohesion to reference ideas across a text · a tadpole … it (pronoun referencing) · the tadpole … it (pronoun referencing) Abstract and technical terms · the life cycle of a frog · stages · tadpole · froglet · adult frogs · the life cycle	The life cycle of a frog has several stages. **First**, a tadpole hatches out of an egg. It looks like a little fish. **Next**, the tadpole grows two back legs and its tail gets smaller. It is now called a "froglet." **Then**, it grows two front legs and the tail gets even smaller. **Finally**, it is a full-grown adult frog with four legs and no tail. Adult frogs can lay more eggs and the life cycle starts again.	**Relate how a series of events causes something to happen through…** Relating verbs · has · is Timeless verbs · hatches · grows Prepositional phrases to provide details about where or when · out of an egg Connectors · **first** · **next** · **then** · **finally**

Image Source: [2020 Edition of WIDA ELD Standards Framework]

Designing a Scope and Sequence/Course Progressions

Elementary K-5

The K-5 NGSS standards are written for each grade level. High-quality curriculum that is rated green in all three gateways from EdReports, will assure your K-5 curriculum is standards-aligned with coherent progressions.

Middle School 6-8

Middle school NGSS are written for the 6-8 grade band and there is flexibility for how alignment and coherence exist in units of instruction and how they progress through the grade band. RIDE no longer prescribes one scope and sequence or advocates for any district developing their own scope and sequence for middle school. Instead, the adoption of high-quality curriculum that is rated green in all three gateways from EdReports, will assure your 6-8 curriculum is standards-aligned with coherent progressions.

High School 9-12

High school NGSS are written for the 9-12 grade band and there is flexibility for how alignment and coherence exist in units of instruction and how they progress through the grade band in the form of courses offered. RIDE no longer prescribes one scope and sequence or advocates for any district developing their own scope and sequence for middle school. Instead, the adoption of high-quality curriculum that is rated green in all three gateways from EdReports, will assure your high school course sequence is standards-aligned with coherent progressions. Districts that don't adopt a curriculum like the example below will need to map each HQIM course independently to verify all standards are met with the appropriate learning progressions for SEP's, CCC's, DCI's, and engineering concepts.

Selecting High-quality Curriculum Materials

RIDE will begin supporting Districts with review, selection, and adoption in 2022. Below are links to resources that are currently supporting ELA and Math. More resources for science will be added accordingly.

Selecting and Implementing a High-quality Curricula In Rhode Island: A Guidance Document: This guidance document outlines the provisions of RIGL§ 16.22.30-33 with regard to adopting high-quality curriculum and includes a list of approved curricula for ELA and Mathematics.

Curriculum Used in Rhode Island: This list and visualization displays which K–12 curricula are being used in each LEA and designates their quality as either *red*, *yellow*, *green*, *not yet rated*, or *locally developed*.

EdReports Curriculum Review Tools for Science

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Section 3: Implementing High-Quality Instruction

Part 1: Introduction and Overview

As described in Sections 1 and 2 of this framework, while robust standards and high-quality curriculum materials (HQCMs) are essential to providing all students the opportunities to learn what they need for success in college and a career of their choosing, high-quality instruction is also needed. Standards define what students should know and be able to do. HQCMs that are aligned to the standards provide educators with a roadmap and tools for how students can acquire that knowledge and skill. It is high-quality instruction that makes the curriculum come alive for students. High-quality instruction gives all students access and opportunity for acquiring the knowledge and skills defined by the standards with a culturally responsive and sustaining approach. “When teachers have great instructional materials, they can focus their time, energy, and creativity on meeting the diverse needs of students and helping them all learn and grow.” (Instruction Partners Curriculum Support Guide Executive Summary, page 2) Executive-Summary-1.pdf (curriculumsupport.org)

The process of translating a high-quality curriculum into high-quality instruction involves much more than opening a box and diving in. This is because no single set of materials can be a perfect match for the needs of all the students that educators will be responsible for teaching. Therefore, educators must intentionally plan an implementation strategy in order to have the ability to translate HQCMs into high-quality instruction. Some key features to attend to include:

- Set systemic goals for curriculum implementation and establish a plan to monitor progress,
- Determine expectations for educator use of HQCMs,
- Craft meaningful opportunities for curriculum-based embedded professional learning,
- Factor in the need for collaborative planning and coaching (Instruction Partners Curriculum Support Guide Executive Summary, page 4) Executive-Summary-1.pdf (curriculumsupport.org), and
- Develop systems for collaboratively aligning HQCMs to the WIDA ELD Standards.

Thus, with a coherent system in place to support curriculum use, teachers will be well-positioned to attend to the nuances of their methods and make learning relevant and engaging for the diverse interests and needs of their students.

Given the above, what constitutes high quality instruction? In short, high-quality instruction is defined by the practices that research and evidence have demonstrated over time as the most effective in supporting student learning. In other words, when teaching is high quality, it embodies what the field of education has found to work the best. Therefore, this section provides a synthesis of research- and evidence-based practices that the Rhode Island Department of Education believes characterizes high-quality instruction in science. This section begins by describing the high-quality instructional practices that apply across content areas and grades with details and examples that explain what these instructional practices look like in science and also explains other specific instructional practices that are at the core of high-quality instruction in *science*. The instructional practices articulated in this section are aligned with and guided by best practices for multilingual learners and for differently-abled students, and specific information and resources are provided about how to support all students in their learning while drawing on their individual strengths. These instructional practices also contribute to a multi-tiered system of supports (MTSS) in which *all* students have equitable access to strong, effective core instruction that supports their academic, behavioral, and social emotional outcomes. This section on instruction ends with a set of resources and tools that can facilitate high-quality instruction and professional learning about high-quality instruction, including tools that are relevant across content areas and grade levels and those that are specific to science.

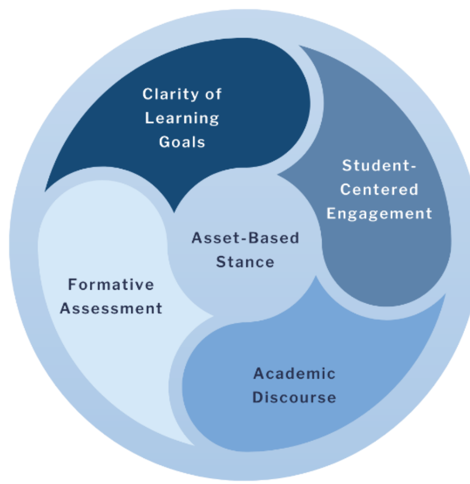
In reviewing this section, use Part 2 to understand what high-quality instruction should look like for all students in science. Use Part 3 to identify resources that can promote and build high-quality instruction and resources for learning more about how to enact high-quality instruction.

Part 2: High-Quality Instructional Practices

In order to effectively implement high-quality curriculum materials, as well as ensure that all students have equitable opportunities to learn and prosper, it is essential that teachers are familiar with and routinely use instructional practices and methods that are research- and evidenced-based. Below are instructional practices that are essential to effective teaching and learning in science. The first set of instructional practices are those common across all disciplines and curriculum frameworks. These are followed by instructional practices specific to science. For additional guidance, there are also descriptions and references to instructional practices that support specific student groups, such as multilingual learners and differently-abled students.

High-Quality Instruction in All Disciplines

Below are five high-quality instructional practices that RIDE has identified as essential to the effective implementation of standards and high-quality curriculum in all content areas (see figure to the right). These practices are emphasized across all the curriculum frameworks and are supported by the design of the HQCMs. They also strongly align with the instructional framework for multilingual learners, the high-leverage practices (HLPs) for students with disabilities, and RIDE's teacher evaluation system. Below is a brief description of each practice and what it looks like in science.



Assets-Based Stance

Teachers routinely leverage students' strengths and assets by activating prior knowledge and connecting new learning to the culturally and linguistically diverse experiences of students while also respecting individual differences.

What This Looks Like in Science

In science, teachers promote equitable teaching and learning when they choose anchoring phenomena or problems that are related to their students lived experience. HQCMs will provide initial phenomena, but teachers can make it relevant by making connections to related, local phenomena. Districts can partner with community resources to incorporate field trips or class visits by STEM experts. This promotes access to student cultures and interests as they navigate sense making routines and engage in the Science and Engineering Practices of NGSS. Our students' prior experiences and knowledge are the assets needed to scaffold their learning of new content and address misconceptions.
Teachers can create equitable learning communities by leveraging diverse student assets and including the student voice in the development of classroom norms. Include all student voices during group sense making, such as the scientists circle where we discuss what we know, need to know, and what we need to do next to learn more about the topic or phenomena. Inclusion of student ideas through discussion, writing ideas and questions on post its, or sketching a model of their current understanding are successful strategies for asset-based instruction.

What this looks like in relation to Universal Design for Learning (UDL)

Differentiated core instruction based in UDL provides access and equity for each student providing multiple options for learning and expression without changing what is being taught. Differentiation is proactive with the goal of adjusting the *how*, based on understanding learner assets and needs, so students may achieve maximum academic growth. High-quality curriculum and instruction implemented through UDL and differentiation support access to grade-level curriculum as part of Tier 1 of a multi-tiered system of supports (MTSS).

What this looks like for Multilingual Learners (MLLs)

Educators with MLLs in their class will support student learning by drawing on MLLs' home languages, lived experiences, and world views. Although RIDE encourages student use of academic registers, it is important that educators and administrators maintain an asset-oriented stance in facilitating academic discourse and student understanding of standard English conventions, particularly when working with learners from minoritized groups. Educational agencies can play a role in sustaining the linguistic traditions of their students. Thus, classroom discourse, when done well, will reflect the discourse practices of local communities—capturing the rich ways families actually use language, rather than making prescriptive judgments about how students and their families ought to talk.

What this looks like for Differently-Abled Students (DAS)

Implementation of HLP 3: Collaborate with Families to Support Student Learning and Secure Needed Services promotes an assets-based stance for students with IEPs. Effective collaboration between educators and families is built on positive interactions in which families and students are treated with dignity. Educators affirm student strengths and honor cultural diversity maintaining open lines of communication with phone calls or other media to build on students' assets and discuss supports or resources. Trust is established with communication for a variety of purposes and not just for formal reasons such as report cards, discipline reports, or parent conferences.

To Learn More

Below is a variety of links to resources to learn more about this practice.

Resource	Description
3 Steps to Developing an Asset-Based Approach to Teaching	**Article** on how to build upon what your students bring to the classroom
Five Ways to Build an Asset-Based Mindset in Education Partnerships	**Article** on developing an asset-based mindset
An Asset-Based Approach to Support ELL Success	**Article** on strategies for engaging and supporting MLLs
HLP #3: Collaborate with Families to Support Student Learning and Secure Needed Services	**Leadership Guide** for HLP #3: Collaborate with Families to Support Student Learning and Secure Needed Services

Resource	Description
Stories from the Classroom: Focusing on Strengths within Assessment and Instruction | Progress Center	**Video** from Progress Center on including students in examining their data and setting ambitious goals by focusing on their assets
TIES TIPS | Foundations of Inclusion | TIP #6: Using the Least Dangerous Assumption in Educational Decisions | Institute on Community Integration Publications (umn.edu)	**Article** on how the least dangerous assumption pushes educators to consider all students as capable. The challenge is to replace a deficit mindset and consider what can educators do to support students in how they access, engage in, and respond not only to both academic and life skills content
Beyond IEPs and 504 Plans: Why You Should Consider Asset-Based Accommodations	**Article** on how asset-based accommodations beyond IEPs and 504s can be effective tools for supporting academic achievement and future success
Classroom Supports: Universal Design for Learning, Differentiated Instruction CTE Series 3 | NTACT:C (transitionta.org)	**Webinar** on the CAST framework of UDL and explanations for how one district incorporates UDL into their CTE programs
MTSS for All: Including Students with the Most Significant Cognitive Disabilities	**Brief** from the TIES Center that provides suggestions for ways in which MTSS can include students with the most significant cognitive disabilities

Clear Learning Goals

Teachers routinely use a variety of strategies to ensure that students understand the following:

1. *What they are learning* (and what proficient work looks like),
2. *Why they are learning it* (how it connects to what their own learning goals, what they have already learned and what they will learn), and
3. *How they will know when they have learned it*.

What This Looks Like in Science

In science, students will follow a coherent storyline where the sequence of lessons allow students to make sense of a phenomena or solve a problem in engineering. A student-centered classroom provides opportunities for students to identify what they are trying to find out (lesson objective) and for teachers to provide opportunities for students to construct explanations with evidence, reflect, and track their progress to identify what they need to find out to explain the phenomena or to solve the problem.

Teachers provide criteria and exemplars when possible so students know what it looks like to be proficient. Student scientist notebooks provide a log for learning and space for students to reflect and set goals. Students will know they have learned specific content or solved a problem because they will receive effective feedback from the teacher and peers and will be able to answer the essential question(s) or solve the problem.

What this looks like for Multilingual Learners (MLLs)

For educators with one or more active MLLs on their roster, clear learning goals for MLLs will consist of explicit language goals to guide instruction in ELA/Literacy. Educators will model effective use of disciplinary academic vocabulary and syntax, creating opportunities every day for explicit disciplinary language development, aligned to the WIDA ELD Standards.

What this looks like for Differently-Abled Students (DAS)

HLP 14, Teach Cognitive and Metacognitive Strategies to Support Learning and Independence, supports the high quality instruction practice of Clear Learning Goals. Through task analysis, educators can support DAS by determining the steps they need to take to accomplish goals, then create and teach a procedure to help the student meet the goals. The educator uses explicit instruction (HLP 16) to teach the student self-regulation strategies such as self-monitoring, self-talk, goal-setting, etc. Clear, step-by-step modeling with ample opportunities for practice and prompt feedback coupled with positive reinforcement (HLP 22) in different contexts over time ensure that DAS become fluent users of metacognitive strategies toward understanding and achieving learning goals. For example, when writing in science, the Self-Regulated Strategy Development approach can support DAS to achieve content area writing goals.

To Learn More

Below is a variety of links to resources to learn more about this practice.

Resource	Description
High-Leverage Practice (HLP) Leadership Guides from the Council for Exceptional Children	**Leadership Guides** for the following HLPs: #11: Identify and Prioritize Long- and Short-Term Learning Goals #12: Systematically Design Instruction Toward Learning Goals #13: Adapt Curriculum Materials and Tasks #14: Teach Cognitive and Metacognitive Strategies to Support Learning and Independence #16: Use Explicit Instruction #22: Provide Positive and Constructive Feedback to Guide Students' Learning and Behavior (academic)
High-Leverage Practice Videos for HLP #11 and HLP #16	**Videos** highlighting **HLP #11** (identify and prioritize long- and short-term learning goals) and **HLP #16** (use explicit instruction) found under "**Access Videos.**"
Culturally Responsive Teaching for Multilingual Learners: Tools for Equity	**Videos** to support culturally responsive and sustaining teaching that showcase strategies, such as activating background knowledge and partnering with MLL families.
Stories from the Classroom: Focusing on Strengths within Assessment and Instruction | Progress Center	**Video** from Progress Center on including students in examining their data and setting ambitious goals

Student-Centered Engagement

Teachers routinely use techniques that are student-centered and foster high levels of engagement through individual and collaborative sense-making activities that promote practice, application in increasingly sophisticated settings and contexts, and metacognitive reflection.

What This Looks Like in Science

In science, student-centered engagement begins with students as collaborators of the class norms. Participation in the student-centered classroom facilitates multiple opportunities for students to work in pairs and collaboratively to collect, analyze, and discuss data. Students share their thinking publicly, ask questions freely, and engage in argumentation frequently. When the teacher brings the class back together as a whole group, they take on the role of facilitator to support sense-making discussion. This careful facilitation and evidence-based argumentation ends with class consensus on what is known and/or needs to be investigated or tested further. Successful engagement of science and engineering practices helps students articulate their thinking, share publicly, and negotiate ideas.

Some successful strategies include Think-Pair-Share, Turn and Talk, Driving Question Boards, KWLN charts, Gallery Walks, Socratic Seminars, Jigsaw activities, collaborative investigating, and the use of a class progress tracker, developing class norms.

What this looks like for Multilingual Learners (MLLs)

Educators with MLLs in their class can promote student-centered engagement by providing scaffolded opportunities for students to build conceptual understanding and fluency with core disciplinary skills, appropriate to their English language proficiency levels.

What this looks like for Differently-Abled Students (DAS)

Student-centered engagement is maximized when educators implement HLP 7, Establish a Consistent, Organized, and Respectful Learning Environment. DAS benefit from educators who explicitly teach consistent classroom procedures and expected behaviors while considering student input. Viewing behavior as communication, reteaching expectations and procedures across different school environments, and helping students understand the rationale for the rules and procedures as part of HLP 7 implementation will enhance student-centered engagement for DAS. In any content area, this may mean providing additional opportunities to for DAS to learn and practice routines that some peers might already have mastered. Some IEPs may call for self-monitoring checklists and visual schedules to support students in active participation in learning activities. Individual DAS will need specific supports unique to their learning profiles. Educators can implement HLP 7 in conjunction with HLP 18, Use Strategies to Promote Active Student Engagement, and HLP 8, Provide Positive and Constructive Feedback to Guide Students' Learning and Behavior, for individualized student supports.

To Learn More

Below is a variety of links to resources to learn more about this practice.

Resource	Description
High-Leverage Practice (HLP) Leadership Guides from the Council for Exceptional Children	**Leadership Guides** for the following HLPs: #7: Establish a Consistent, Organized, and Respectful Learning Environment #8: Provide Positive and Constructive Feedback to Guide Students' Learning and Behavior #17: Use Flexible Groupings #18: Use Strategies to Promote Active Student Engagement #21: Teach Students to Maintain and Generalize New Learning Across Time and Settings
Fundamental Skill Sheets Videos	**Video playlist** from the Iris Center: Choice Making, Proximity Control, Wait Time, Behavior Specific Praise
High-Leverage Practices Video: Use Strategies to Promote Active Student Engagement	**Video** highlighting HLP #18 which focuses on strategies to promote active student engagement
Including Voice in Education: Addressing Equity Through Student and Family Voice in Classroom Learning	**Infographic** on incorporating student voice and/or family voice into student learning, a promising strategy for teachers striving to foster culturally responsive and sustaining classrooms to enhance education access, opportunity, and success for students who are historically marginalized within the pre-kindergarten to grade 12 education systems
SEL for Self-Management	**RIDE resources** on Social Emotional Learning Indicators for Self-Management
SEL for Social Awareness	**RIDE resources** on Social Emotional Learning Indicators for Social Awareness
WWC | Organizing Instruction and Study to Improve Student Learning (ed.gov)	**Guide** including a set of concrete actions relating to the use of instructional and study time that are applicable to subjects that demand a great deal of content learning, including social studies, science, and mathematics. The guide was developed with some of the most important principles to emerge from research on learning and memory in mind. • Space learning over time. • Interleave worked example solutions with problem-solving exercises. • Combine graphics with verbal descriptions. • Connect and integrate abstract and concrete representations of concepts. • Use quizzing to promote learning. Use quizzes to re-expose students to key content. • Ask deep explanatory questions.

Academic Discourse

Teachers routinely facilitate and encourage student use of academic discourse through effective and purposeful questioning and discussion techniques that foster rich peer-to-peer interactions and the integration of discipline-specific language into all aspects of learning.

What This Looks Like in Science

Teachers routinely engage in teaching practices that support discourse to elicit student ideas, for asking questions, constructing explanations, obtaining and communicating information, arguing from evidence, and coming to consensus as a class. In this way discourse is the sense making vehicle for all aspects of carrying out an investigation, not just at the beginning and end of a lesson directed by the teacher.

In a rich student-centered classroom, discourse norms are well established and language supports for science discourse are scaffolded with talking stems and accountable talk criteria.

“Characteristics of productive talk include the following:

- Students listening closely to one another
- Students doing the heavy lifting of
    - Explaining their ideas
    - Reasoning with evidence and models
    - Building on the thinking of others (agreeing, disagreeing, and questioning)
    - Making thinking –questions, models, data, arguments, explanations – public and visible
- Students and the teacher working together to clarify, challenge, and improve the groups’ thinking
- Equitable participation
- Risk-taking and opportunities for students to revise their thinking” (Schwarz, Passmore, & Reiser, 2017, p.315)

The Talk Science Primer (https://inquiryproject.terc.edu/shared/pd/TalkScience_Primer.pdf) outlines the elements of academically productive talk and discusses how teachers can establish a culture of productive discourse. The Talk Science Primer provides specific methods for use with students in science classes and provides a series of Talk Moves that can elicit more of what students understand.

Argumentation is a specific discourse used in the science classroom, aligned with science and engineering practice #7. It is the process used to develop explanations for phenomena or solutions to engineering problems. The Argumentation Toolkit (http://www.argumentationtoolkit.org/) is a collection of resources that were developed by the Lawrence Hall of Science to help teachers understand and teach scientific argumentation. The argumentation toolkit includes strategy guides and teacher learning modules.

What this looks like in relation to Social Emotional Learning

The five core competencies of Rhode Island’s Social Emotional Learning standards and indicators support academic discourse across the content areas. Learners must engage effectively in a range of collaborative discussions with diverse partners, building on each other's' ideas and expressing their own clearly.

- Self-Awareness: Identifying one's strengths and weaknesses while working within a group, staying motivated and engaged throughout the work.
- Self-Management: Controlling one's emotions, responding calmly to comments, questions, and nonverbal communication.
- Social-Awareness: Understanding others' perspectives and cultures, compromising with peers when the situation calls for it, accepting feedback from peers and teachers, listening to the opinions of others and taking them into consideration.
- Relationship Skills: Expressing one's perspective clearly, following agreed upon rules of the group and carrying out assigned role(s), gaining peers' attention in an appropriate manner, asking questions of group members, limiting the amount of information shared with others, and actively listening to peers when they speak.
- Responsible Decision Making: Coming to the group prepared, demonstrating independence with work tasks, dividing labor to achieve the overall group goal efficiently.

Social and emotional skills are implicitly embedded in the content standards, and students must learn many social and emotional competencies to successfully progress academically. Social Emotional Learning skills are instrumental for each student and are crucial for differently-abled students.

What this looks like for Multilingual Learners (MLLs)

Though beneficial for all students, academic discourse is especially important for MLLs because engaging in authentic interaction with discipline-specific oral language facilitates MLLs' overall development of English language proficiency. In RIDE's *High-Quality Instructional Framework for MLLs to Thrive*, academic discourse is defined as a sustained spoken interaction between two or more students in which knowledge is shared using the conventions of particular genres and disciplines.

What this looks like for Differently-Abled Students (DAS)

Educators plan mixed-ability small groups to increase DAS student engagement in academic discourse through a variety of cooperative learning structures consistent with HLP 17, Use Flexible Groupings. Effective groupings are monitored for learning and student interactions to meet various academic, behavioral, and interpersonal instructional objectives. DAS may require varied group sizes and types based upon specific IEP goals and accommodations. A student engaging in intensive instruction of a particular math or reading skill may do so in a supplemental homogenous group of only 2-3 peers while also having regular opportunities to engage in heterogeneous collaborative groups during core instruction with scaffolded supports.

To Learn More

Resources to support productive discourse in the science classroom

Resource	Description
#25 Cultural Argumentation	Educators can use these strategies to help foster argumentation that is culturally responsive and sustaining, meaning it draws from and respects students' cultural resources, backgrounds, and personal experiences.
#6 Productive Science Talk	How to support students in "sense-making" talk to help them work through their understanding while engaging in the science and engineering practices.
How can I foster curiosity and learning in my classroom? Through talk!	Specific instructional approaches—or 'talk activities'—can be used to support students' three-dimensional science learning. Our Talk Activities Flowchart, this tool highlights those talk formats and explains when, how, and why to use each talk format in support of student investigations.
How can arguing from evidence support sensemaking in elementary science?	Arguing from evidence is a key scientific practice to support sense making in a learning community. As children collect and grapple with patterns in data to understand phenomena, differing perspectives naturally arise.
Doing and Talking Math and Science: Strengthening Reasoning, Strengthening Language	**Discourse Move Cards** for students and teachers in STEM classrooms
High-Leverage Practice (HLP) Leadership Guides from the Council for Exceptional Children	**Leadership Guides** for the following HLPs: #15: Provide Scaffolded Supports #17: Use Flexible Groupings
High-Leverage Practice Video: Use Flexible Groupings	**Video** highlighting HLP 17 which focuses on using flexible groupings
Instruction | High-Leverage Practices	**Resources for high-leverage practices related to instruction.** When instruction is well designed, strategic, and adaptable, special education teachers have the skills to improve student learning.
TIES TIP #2: Using Collaborative Teams to Support Students with Significant Communication Needs in Inclusive Classrooms	**Tip sheet** on additional planning for general and special education teachers as well as related service providers. These include speech-language pathologists, physical and occupational therapists, and vision/hearing specialists. Coordinating the work of these service providers and leveraging their expertise can result in a high-quality experience for all the learners in an inclusive class.

Formative Assessment

Teachers routinely use qualitative and quantitative assessment data (including student self-assessments) to analyze their teaching and student learning in order to provide timely and useful feedback to students and make necessary adjustments (e.g., adding or removing scaffolding and/or assistive technologies, identifying the need to provide intensive instruction) that improve student outcomes.

What This Looks Like in Science

Formative assessment in science incorporates multiple modalities such as oral responses through talk moves, use of media, initial student models, written expression, and may include short and longer constructed responses to prompts. Formative assessments attend to multilingual learners and differently-abled learners by providing appropriate scaffolds.

What this looks like for Multilingual Learners (MLLs)

For educators with one or more active MLLs on their roster, formative assessment practices should include the collection of discipline-specific language samples and progress monitoring of MLLs' language development in science. These language samples and assessment practices will give educators the data needed to provide students with language-focused feedback aligned to their language goals for science. When designing or amplifying formative assessments for disciplinary language development, educators should draw on the English language proficiency level descriptors for their grade level(s) in the WIDA ELD Standards Framework. For additional information about how these descriptors can assist educators in offering targeted feedback based on the word, sentence, or discourse level dimension of students' language samples, please see Section 4 of the Science Curriculum Framework.

What this looks like for Differently-Abled Students (DAS)

HLP 4, Use Multiple Sources of Information to Develop a Comprehensive Understanding of a Student's Strengths and Needs, describes assessment as a collaborative process that includes informal assessments to plan instruction that is responsive to individual needs. DAS participation in formative assessments may require specific accommodations specified in IEPs. Implemented in conjunction with HLP 22, Provide Positive and Constructive Feedback to Guide Students' Learning and Behavior, DAS will receive immediate and specific feedback on their performance that is goal-directed and thoughtful in considering the specific learner profile. Feedback on formative assessment is positive and constructive when it avoids words like "should, but, however" and includes statements that highlight what they did appropriately followed by a question (what is another way?) or a suggestion (try adding or continuing with). A diagram or image can support DAS to understand feedback and their progress on formative assessments.

To Learn More

Below is a variety of links to resources to learn more about this practice.

Resource	Description
Research Brief: The Informal Formative Assessment Cycle as a Model for Teacher Practice	In this study, researchers studied three teachers with varying informal assessment practices to explore the

Resource	Description
	nature of informal formative assessment and its connection to student learning.
CCSSO Revising the Definition of Formative Assessment	This resource provides an overview of the FAST SCASS's revised definition on formative assessment, originally published in 2006. The revised definition includes an overview of the attributes of effective formative assessment and emphasizes new areas emerging from current research, theory, and practice.
High-Leverage Practice (HLP) Leadership Guides from the Council for Exceptional Children	**Leadership Guides** for the following HLPs: #4: Use Multiple Sources of Information to Develop a Comprehensive Understanding of a Student's Strengths and Needs #6: Use Student Assessment Data, Analyze Instructional Practices, and Make Necessary Adjustments that Improve Student Outcomes HLP #8: Provide Positive and Constructive Feedback to Guide Students' Learning and Behavior (SEL) #22: Provide Positive and Constructive Feedback to Guide Students' Learning and Behavior (academic)
High-Leverage Practices Video: Provide Positive and Constructive Feedback to Guide Students' Learning and Behavior	**Video** highlighting HLPs #8 and #22 on providing positive and constructive feedback to guide students' learning and behavior. This resource supports both SEL and academic domains.
Stories from the Classroom: Focusing on Strengths within Assessment and Instruction | Progress Center	**Video** from Progress Center on including students in examining their data and setting ambitious goals
Assessment | High-Leverage Practices	**Resources** for using multiple sources of assessment, communicating assessment data, and using data to inform instruction

High-Quality Instruction in Science

In addition to being researched based, high-quality science instructional practices are designed for the three-dimensional teaching and learning of NGSS and facilitate the differentiation of instruction to build student knowledge equitably. The three shifts described in the vision of the *Framework for K–12 Science Education* (NRC, 2012) include (1) explaining phenomena and designing solutions to problems, (2) engaging in three-dimensional learning, and (3) building coherent learning progressions over time.

To achieve this vision, effective instruction in science will incorporate a student-centered approach to making sense of the natural world by integrating investigations where students engage in science and engineering practices to find answers to their questions in a logical sequence where discrete knowledge is learned in a coherent manner.

In *Helping Students Make Sense of the World*,

"Making sense of the world, or sense-making for short, is the fundamental goal of science and should be the core of what happens in science class rooms…An observer should be able to walk into a science classroom on any given day and ask, "What are you trying to figure out right now?" The intellectual aim of any work in the science class should be clear to everyone. Rather than stating, "We are learning about photosynthesis or plate tectonics," students should be able to say (and believe!), "We're trying to figure out how a tiny seed becomes this huge oak tree" or "We're trying to better understand why volcanoes and earthquakes happen more often in some parts of the world." These examples illustrate how the students are figuring out the world and illustrate a sense-making goal in the classroom." (Schwarz, Passmore, & Reiser, 2017, pp. 6-7)

The following instructional approaches are examples that illustrate what high-quality instruction in science can look like to incorporate the shifts and achieve the vision of the *Framework for K–12 Science Education.*

Example A – Storyline Approach With 5 Core Routines

In Reiser, B. J., Novak, M., & McGill, T. A. W. (2017*),* by teaching NGSS through a coherent storyline that begins with a phenomenon, one can engage student curiosity in the science and engineering practices through investigations (often hands-on) that lead to new knowledge, or sense-making, of the limited disciplinary core ideas related to the engaging phenomenon.

Effective instructional practices for teaching with this storyline, mindset include five specific routines (Rieser et al., 2017).

1. Introduction of the anchoring phenomenon routine
    a. Explore the phenomenon (notice and wonder)
    b. Attempt to make sense (elicit student ideas)
    c. Identify related phenomena (local context or examples)
    d. Students develop questions that need to be answered (made public with a driving question board)
2. Navigation Routine
    a. Looking back – Where did we leave off?
    b. Looking forward – What are we trying to figure out? How can we work on this today?
    c. Engage in the lesson with SEPs – What have we agreed upon? Where are we not sure? Where should we go?
3. Investigation Routine
    a. Engage in scientific practices to find answers to initial questions and confirm or refute initial ideas.
    b. Identify what has been figured out (disciplinary core ideas and cross-cutting concepts)
    c. Identify new questions we have now.
4. Problematizing Routine
    a. Revise initial explanations or models based on new information.
    b. Identify what's missing and what still needs to be uncovered.
5. Putting the pieces together

a. Prompt students to identify what has been figured out through multiple investigations through engagement in scientific discourse.
b. What questions on the driving question board about the phenomena can be answered form our new knowledge?
c. Come to consensus as a class.
d. Revise initial explanations and/or models to reflect what has been discovered about the anchoring phenomena.

Reiser, B. J., Novak, M., & McGill, T. A. W. (2017*). Coherence from the students' perspective: Why the vision of the framework for K-12 science requires more than simply "combining" three dimensions of science learning. Paper commissioned for the Board on Science Education workshop "Instructional materials for the Next Generation Science Standards". Retrieved from http://sites.nationalacademies.org/cs/groups/dbassesite/documents/webpage/dbasse_180270.pdf*

For more information on teaching with coherent storylines visit: [http://www.nextgenstorylines.org/.](http://www.nextgenstorylines.org/)

Example B – Open Education Resource (OER) OpenSciEd Instructional Model
This approach also uses storylines to build upon student questions from an engaging phenomenon in science. OpenSciEd describes how instructional practices are built into a model of the five routines to help students achieve the objectives of a single or bundle of performance expectations, (OpenSciEd, 2021).

Take a deeper dive with the OER OpenSciEd Instructional Model:
https://www.openscied.org/wp-content/uploads/2019/08/Aug-2020_-Beta-Open-SciEd-Teacher-Handbook.pdf
Science Classroom Resources - Science Model Design. (2021, April 09). Retrieved May 06, 2021, from https://www.openscied.org/openscied-instructional-model/

Other High-quality Lesson Examples:
"In an effort to identify and shine a spotlight on emerging examples of high-quality lessons and units designed for the NGSS, Achieve launched the EQuIP Peer Review Panel for Science (PRP). The PRP uses the EQuIP Rubric for Science (Version 3.0) and the associated quality review process to evaluate the instructional materials.

The objective is not to endorse a particular curriculum, product or template, rather to identify lessons and units that best illustrate the cognitive demands of the NGSS. The list of instructional materials that have been submitted to the EQuIP Peer Review Panel and evaluated as Examples of High-quality NGSS Design, Examples of High-quality NGSS Design if Improved, or Quality Works in Progress." (https://www.nextgenscience.org/resources/examples-quality-ngss-design, 2021)

See more examples here: [Quality Examples of Science Lessons and Units]()

To Learn More
Below is a variety of links to resources to learn more about this practice.

Resource	Description
[Three-Dimensional Phenomenon-based Instruction]()	For more information on using Phenomena in NGSS-Designed Lessons and Units, see this overview of

Resource	Description
	what phenomena are and why they are used to drive lessons and units that are aligned to NGSS
Teaching the cross-cutting concepts explicitly	A set of class prompts arranged by the CCCs, to elicit student understanding of CCCs in the context of investigating phenomena or solving problems support explicit integration of the cross-cutting concepts and can be found here

Evidence-Based Practices for Supporting Integration of STEM

RIDE is committed to increasing access to high-quality STEM educational opportunities for all students. An understanding of STEM concepts and development of STEM-related skills is needed to prepare future generations to make informed choices and increase the number of qualified candidates for careers in Rhode Island's growing STEM industries.

The acronym, STEM, was coined by the National Science Foundation (NSF) in 2001 to describe occupations that required knowledge and skills from the disciplines of Science, Technology, Engineering, and Mathematics. Beyond conceptual understanding, STEM occupations require the application of concepts across disciplines. In 2010, the Rhode Island School of Design (RISD) campaigned to add Art and Design to the acronym by revising it to STEAM. This addition shifted the term to highlight the more innovative aspects of creativity and problem-solving. The U.S. Bureau of Labor Statistics anticipates the number of STEM occupations to grow an additional 8 percent by 2029, compared with 3.7 percent for non-STEM occupations in the same period. To ensure that students have the knowledge and skillset to be successful in STEM occupations, all students need to engage in STEM experiences that focus on application and problem-solving throughout their education. Engaging in well-designed, grade-level appropriate STEM activities from an early age will give all students experiences where they can apply concepts and skills acquired in core classes to develop innovative solutions to local and global problems.

The individual subject areas of science, technology, engineering, and mathematics are the disciplines of STEM, where a solid foundation is built. Building from this, students need to engage in *Integrated* STEM, where experiences apply the knowledge and skills from several (or all) of the STEM disciplines. Time for Integrated STEM should be provided beyond the time allotted for mathematics and science instruction since these subjects have tightly packed curricula that need to be followed with fidelity. An increasing number of schools have supplemental, in-school STEM/STEAM programs for elementary students and STEM/STEAM courses for middle and high school students. These in-school opportunities need to be part of every student's experience, not just offered as electives or as enrichment for high achieving students.

Planning for STEM (or STEAM) Integration

- Integrated STEM experiences should support the development of disciplinary knowledge while making cross-discipline connections explicit to students. Educators must thoughtfully design Integrated STEM experiences that provide intentional support for students to build knowledge and skill both within the disciplines and across disciplines.
- Educators need to ensure that STEM experiences reinforce the student learning in science and mathematics, but do not undermine or duplicate the core subject curriculum.
- When designing Integrated STEM experiences, it is important to use the grade-level science and mathematics standards and learning progressions. Additionally, the Standards for Technology and Engineering Literacy (STEL) (ITEEA, 2020) should be used to guide to ensure that the experiences are appropriate for the developmental level of the students and develop students' technology and engineering proficiencies.
- Instructional models such as project-based/problem-based learning provide authentic opportunities for students to engage in Integrated STEM. Educators should design experiences that are grade-level appropriate and draw on student and/or community interest. The learning experiences should be iterative, annually reviewing them to incorporate new ideas or technology and to include novel student interests or community concerns.
- Integrated STEM education should not take the place of high-quality education focused on the individual STEM subjects, but it should require students to apply the knowledge and skills of the STEM subjects. While teachers should integrate STEM into math and science courses where it naturally fits, students need more opportunities to engage in Integrated STEM in school. Since the Next Generation Science Standards (NGSS) include engineering performance expectations as well as the practice of analyzing and interpreting data, there is some expected integration of the other STEM disciplines. Additional opportunities to engage in Integrated STEM will give students motivation to apply what they are learning in STEM discipline areas and advance their learning.

Real-World & Career Connections

- All students should view a career in STEM as accessible; engaging all students in STEM throughout K–12 is an important part of creating this perspective. Providing access to STEM experiences where students are challenged but can find success can lead to an interest in STEM careers. Schools and educators need create a climate that provides all students, especially those from underrepresented groups in STEM career fields, access and the opportunity to be successful in STEM learning. Partnering with local STEM organizations and industries will allow students to better understand the opportunities that exist through interaction with STEM professionals, exploration of potential careers, and understanding the variety of STEM-related workplaces. Industry partnerships can start at an early age as part of career awareness, later progressing to career exploration, and potentially including high school internships or pre-graduation training programs.
- Even if students do not follow a STEM career path, they will still need to acquire STEM literacy. STEM literacy includes the ability to be a critical consumer of information, be a creative problem solver, and develop critical thinking skills. Thoughtfully designed Integrated STEM experiences also build the Cross-Curricular Proficiencies of collaboration, communication, problem-solving and critical thinking, reflections and evaluation, and research. These skills will support all students to be lifelong learners and have success in college and career.

Equitable Access to STEM

- Assuring access to STEM experiences for learners traditionally underrepresented in STEM fields can provide opportunities for individual success as well as broader changes to the STEM workforce. Additionally, engaging learners in STEM-related problem-based learning provides motivation and engagement not found in decontextualized academic knowledge. (Parker et al, 2016)
- Access is only one aspect of equity, schools also need to look carefully at how their course design and strategies encourage broadened participation through alternative ways of thinking about motivation, engagement, and persistence. Equity needs to be addressed with targeted strategies that align with the local context and realities of the learners, whether geographic (e.g., experiences of rural learners), social (e.g., experiences of girls), or experiential (e.g., experiences of students with disabilities). At the same time, strategies that are explicitly aligned to broadening participation in STEM also improve STEM experiences for all students. (Parker et al, 2016)

To Learn More

Below is a variety of links to resources to learn more about this practice.

Resource	Description
My PBLWorks from Buck Institute	To help schools and districts visualize high-quality PBL in the classroom, the Buck Institute for Education (BIE) has videos showcasing PBL projects from K–12 schools nationwide, including several STEM-themed projects. Teachers can view videos of successful PBL projects that feature teacher interviews and actual classroom footage and highlight projects from a range of grade levels, settings, and subject areas, including STEM.
STEMWorks at WestEd	STEMworks is a searchable online honor roll of high-quality science, technology, engineering, and mathematics (STEM) education programs. STEMworks helps companies, states, and individuals make smart investments in their communities by evaluating and cataloging programs that meet rigorous and results-driven design principles.
National Science Foundation (NSF) Resources for STEM Education	NSF research and development projects have produced a rich array of principles, materials, and practitioner insights that are helpful guides to improved preparation and professional development of STEM teachers. The following examples illustrate the range of ideas and products available from that work.

High-Quality Instruction for Multilingual Learners

The development of a second, third, or fourth language is a lifelong process — one that cannot take place in isolation or within a stand-alone hour of the school day. If we are to ensure all students have meaningful access to core instructional programs, all educators must share responsibility for the education of MLLs, including teachers of ELA/Literacy. For those not certified in English to Speakers of Other Languages or Bilingual/Dual Language, shared responsibility might beg the question: What is high-quality instruction for MLLs? What practices are evidence-based in promoting content and language learning with MLLs?

RIDE offers in-depth guidance about the key components of high-quality MLL instruction in its *High-Quality Instructional Framework for MLLs to Thrive*, but the research is clear: language development is most effective when integrated within content area instruction. Integrated language and content teaching gives MLLs rich, highly contextualized opportunities to use disciplinary language, which in turn reinforces content learning. Rather than teaching a discrete set of grammar rules or vocabulary lists, devoid of disciplinary context, educators must reflect on the language demands of content-based tasks from the core curriculum, offering explicit language instruction and ample scaffolds so MLLs can linguistically access and engage in core content area instruction.

To Learn More

Below is a variety of links to resources to learn more about this practice.

Resource	Description
Strategies for Supporting Emerging Multilingual Learners' Sensemaking	Science and engineering practices require complex use of language. In order for emerging multilingual learners (EMLs) to have equitable opportunities to engage in science and engineering practices, teachers must be able to both leverage these students' linguistic resources and address the language needs that they may have.
WIDA ELD Standard 4 – Language of Science	The English Language Development Standards provide a framework for NGSS aligned instruction to support teaching and learning of multilingual learners.
Engaging English Learners in the Science and Engineering Practices	The practices can be seen as a barrier to participation for English Learners (ELs), or they can be viewed as an opportunity to provide rich instruction that builds science-related competencies and identities. Teachers should know NGSS practices are heavily language-dependent — and teach accordingly to make experiences inclusive for multilingual students.
WIDA Focus Bulletin- Collaboration: Working Together to Serve MLLs	**Article** with overview of language-focused collaborative teaching models and cycles
Collaborative Planning for Content and Language Integration: A Jump-Off Point for Curricular Conversations	**Sample Collaborative Planning Process** in the WIDA ELD Standards Framework that gives a scenario with a 7th grade science classroom

Resource	Description
Professional Learning: Purposeful Instructional Design Part 1 Professional Learning: Purposeful Instructional Design Part 2	**Self-paced courses** on designing asset-based core instruction for MLLs This two-part course sequence is available on BRIDGE-RI, the learning management system for Multi-Tiered System of Supports (MTSS) in the state of Rhode Island. Educators can participate in these professional learning opportunities online at no cost. Critical aspects of Part 1 include: Tier 1 instructional design, data collection, and use of evidence-based instructional delivery practices for language learners, such as scaffolds. Critical aspects of Part 2 include: the role of physical environment and classroom climate in teaching and learning as well as translanguaging strategies and cross-linguistic features of common home languages.
Professional Learning Communities Facilitator's Guide for the What Works Clearinghouse Practice Guide Teaching Academic Content and Literacy to English Learners in Elementary and Middle School	**Videos** and **Facilitator's Guide** for four evidence-based practices: promoting academic vocabulary, integrating language and content instruction, providing structured opportunities to engage in writing activities, and conducting small-group interventions.
The GO TO Strategies: Scaffolding Options for Teachers of English Language Learners, K-12	**Implementation Guide** for educators with a list of scaffolding strategies for MLLs
Focusing Formative Assessment on the Needs of English Language Learners	**Article** about conducting formative assessments with MLLs
Using Formative Assessment to Help English Language Learners	**Article** about conducting formative assessments with MLLs

High-Quality Instruction for Differently-Abled Students

Equity requires participation and a sense of belonging. To ensure that all students participate in science instruction — not just the hand raisers — teachers will need a continuum of proactive strategies that increase opportunities for student engagement. Students with IEPs or a 504 plan are general education students who access the grade-level curriculum through the support of high-quality instruction, as described in the preceding sections, which utilizes data on learner characteristics to differentiate and scaffold. Accommodations determined by the IEP team or a 504 plan complement the differentiation and scaffolds to ensure that accessibility needs specific to the individual learner are met. General education and content area teachers are responsible for providing instruction that is differentiated, scaffolded, and where appropriate for individual learners, includes accommodations. Some learners will also require instructional modifications as determined by the IEP team. When students receive quality supplementary curricula as part of their specially designed instruction (SDI), then inclusion can provide accommodations for generalizing skills they mastered in SDI. Collaborative planning with special educators and related service providers will support general educators in developing their repertoire of rigorous and accessible instructional practices.

The Leadership Implementation Guides from the High Leverage Practices for Students with Disabilities include tips for school leaders to support teachers; questions to prompt discussion, self-reflection and observer feedback; observable behaviors for teachers implementing the HLPs; and references and additional resources on each HLP. These guides, referenced throughout this section, were developed to help leaders integrate the HLPs into professional development and observation feedback.

Understanding learner characteristics will help clarify what types of support to provide to DAS in their planning, organizing, and writing to promote DAS access and progress in the science curriculum. A combination of techniques such as guided inquiry, science notebooks and Self-Regulated Strategy Development (SRSD) provides scaffolding to promote the success of DAS. Any accommodations outlined per the IEP or a 504 plan that provide reading, writing, and math access will be important for science (Collins & Fulton, 2017).

To Learn More

Below is a variety of links to resources to learn more about this practice.

Resource	Description
High-Leverage Practice (HLP) Leadership Guides from the Council for Exceptional Children	**Leadership Guides** for the following HLPs: #1: Collaborate with Professionals to Increase Student Success #5: Interpret and Communicate Assessment Information with Stakeholders to Collaboratively Design and Implement Educational Programs #14: Teach Cognitive and Metacognitive Strategies to Support Learning and Independence
Unit Co-Planning for Academic and College and Career Readiness in Inclusive Secondary Classrooms	**Article** describing the UCPG, a tool to support general and special education teacher collaboration and planning in inclusive general education classrooms
Big Ideas in Special Education: Specially Designed Instruction, High-Leverage Practices, Explicit Instruction, and Intensive Instruction	**Article** describing the differences between specially designed instruction, high-leverage practices, explicit instruction, and intensive instruction
IEP Tip Sheet: What are Supplementary Aids & Services?	**Tip Sheet** from Progress Center on Accommodations for instruction and assessment, modifications, and other aids and services
IEP Tip Sheet: What are Program Modifications & Supports?	**Tip Sheet** from Progress Center on program modifications and supports that promote access to

Resource	Description
	and progress in general education programming and shares tips for implementation
Can you implement DBI to support students with intellectual and developmental disabilities?	In this brief **video**, Dr. Chris Lemons shares considerations for implementing data-based individualization (DBI) to support students with intellectual and developmental disabilities
Classroom Supports: Universal Design for Learning, Differentiated Instruction CTE Series 3 | NTACT:C (transitionta.org)	**Webinar** from the National Assistance Center on Transition — UDL at secondary: "Fundamentals of differentiated instruction to support effective teaching, individualized learning and maximize student engagement are shared."
TIES Center: Inclusive Instruction: Resources on Inclusive Instruction	**Resources on Inclusive Instruction:** TIES Brief #4: Providing Meaningful General Education Curriculum Access to Students with Significant Cognitive Disabilities TIES Brief #5: The General Education Curriculum- Not an Alternative Curriculum! Lessons for All: The 5-15-45 Tool
TIES Center: TIES TIPS: Foundation of Inclusion TIPS	**TIES Inclusive Practice Series TIPS** #15 Turn and Talk in the Inclusive Classroom #16 Making Inferences in the Inclusive Classroom #19 Creating Accessible Grade-level Texts for Students with Cognitive Disabilities in Inclusive Classrooms
Evidence-based practices for children, youth, and young adults with Autism	**Report** on evidence-based practice including a fact sheet for each that provides a longer description, information about participant ages and positive outcomes, and a full reference list.

Evidence-Based Practices for Supporting Culturally Responsive & Sustaining Education (CRSE)

Resource	Description
How to avoid possible pitfalls associated with culturally responsive instruction	For the purposes of equity, it is crucial for science teaching to make meaningful connections to the cultural knowledge, experiences, and ways of knowing of students and their communities. Learn how to engage in culturally responsive and sustaining

Resource	Description
	instruction — but avoid possible pitfalls that come with this important work.
How to build an equitable learning community in your science classroom	Equitable classroom communities foster trusting and caring relationships. Teachers can use these activities to improve equitable opportunities for students.
Overview: How can we promote equity in science education?	Equity should be prioritized as a central component in all educational improvement efforts. All students can and should learn complex science. However, achieving equity in science education is an ongoing challenge. Teachers can work with colleagues to implement instructional strategies to make science learning experiences more inclusive for all students.
Social and Emotional Learning for All	This is a RIDE link providing a robust collection of resources for educators and administrators.

Part 3: Resources for Professional Learning

Enacting the high-quality instructional practices described above is an essential yet complex task for teachers. Thus, ensuring high-quality instruction for all students in school often requires a team effort involving grade-level/content-area teachers, specialists and educators working with multilingual learners and differently-abled students in particular, and the administrators, leaders, and coaches who support all the educators. In addition, effective professional learning that helps teachers enhance their knowledge and application of high-quality instructional practices should strategically integrate multiple types of professional learning, as described in this section.

First, as mentioned in earlier sections of this framework, high-quality instruction begins with a deep understanding of the standards since they provide the foundation for instruction by defining what students need to know and be able to do. Professional learning suggestions and guidance for deepening the understanding of standards can be found in Section 2 of this framework.

Professional learning for high-quality instruction must also focus on developing a solid understanding of the high-quality instructional practices listed above. Readers are encouraged to review the many resources listed with each instructional practice and to establish 'book study' groups with colleagues to read, review and discuss any of the resources shared in Part 2 of this section of the framework.

In addition, supporting effective professional learning requires supporting teachers' application of the practices described above. As with any complex skill, when supporting the application of high-quality instructional practices, the key ingredient is timely and targeted feedback. For feedback to be provided in a targeted and timely fashion, practices must be made visible so that the application of instructional practices can be observed. Once observed, feedback can then be generated. Most of the professional learning tools designed to provide feedback align with three key phases of the instructional cycle where it is very helpful for teachers to receive feedback about their instruction. The first phase is during lesson planning, before instruction actually takes place. The next phase is the actual instruction where teachers can be observed engaging with students. The final phase is after teaching has taken place and focused on the review of student work and evidence of learning. Below are a variety of tools and resources that are designed to provide teachers with feedback during these three phases. They are organized into the following three categories: Planning Tools, Observation Tools, and Evidence of Learning Tools. These tools come from a variety of sources, but all are intended to guide coaches, professional learning providers, and other leaders in offering support to teachers in this work.

Planning Tools

Resource	Description
Lesson structures: [Lesson Screener]	"The purpose of the Next Generation Science Standards (NGSS) Lesson Screener is to quickly review a lesson to see: (1) whether a lesson being developed or revised is on the right track; (2) if a lesson warrants further review using the Educators Evaluating the Quality of Instructional Products (EQuIP) Rubric for Lessons & Units: Science (see further detail below); and (3) to what extent a group of reviewers have a common understanding of the NGSS or designing lessons for the NGSS."
EQuIP Rubric for Science	"The EQuIP Rubric for Science Detailed Guidance provides details on each of the 19 EQuIP Rubric criteria, including what they look like in materials, connections between the criteria, and some common pitfalls." (EQuIPDetailedGuidanceMarch2021.pdf http://www.nextgenscience.org, 2021)
Vertical alignment tool/Learning Progressions: K-12 Progressions	The NGSS are intended to increase coherence in K–12 science education. This document supports teacher planning for instruction by understand what prior experiences students have for current learning of disciplinary core ideas and what future learning students will encounter. A quick reference guide to ensure the core is taught at the appropriate level within its progression.
30-Minute Tuning Protocol	**Protocol** designed to be used within collaborative teacher teams. It can be used to provide teachers with feedback on any artifact of their teaching and is a great tool to solicit feedback about lessons. In the protocol, a presenting teacher shares the goal, need, and plan of their professional work. Participants share feedback in rounds. The presenter then reflects on what was said that was helpful and what feedback they will try to incorporate to improve their plan.
EdReports for Resources	A resource guide for districts in the review and adoption phase of high-quality instructional materials.

Resource	Description
	These tools will help your committee determine the needs of your teaching and learning community and outline the major considerations for engaging in the process.
Quality Examples of Science Lessons and Units	"In an effort to identify and shine a spotlight on emerging examples of high-quality lessons and units designed for the NGSS, Achieve launched the EQuIP Peer Review Panel for Science (PRP). The objective is not to endorse a particular curriculum, product or template, rather to identify lessons and units that best illustrate the cognitive demands of the NGSS. Below is the list of instructional materials that have been submitted to the EQuIP Peer Review Panel and evaluated as Examples of High-quality NGSS Design, Examples of High-quality NGSS Design if Improved, or Quality Works in Progress." (Quality Examples of Science Lessons and Units | Next Generation Science Standards http://www.nextgenscience.org, 2021)
Co-Planning Tool	The WiS Co-Planning Tool is a research-based tool to help co-teaching teams of special educators and their science educator peers plan writing instruction to prioritize science content learning, meet the CCSS and NGSS, and support DAS. Educators plan around four components to implement effective writing instruction in science (i.e., writing purposes, writing tasks, evidence-based practices for teaching writing, and additional adaptations to support DAS.)
UDL Tip for Designing Learning	**Tip sheet** with teacher questions, examples, and further resources to help anticipate learner variability and make instruction flexible and useful for all learners
CAST | Key Questions to Consider When Planning Lessons	**One-pager** of question prompts for teacher to improve lesson accessibility
Whole Group Response System	**Article** on whole-group response systems paired with formative assessment charts to provide instruction that actively engages students in the learning process "These strategies can be implemented easily in classrooms with minimal additional resources and are applicable across grade levels and content areas with appropriate modifications."

Resource	Description
Approaching Explicit Instruction Within a Universal Design for Learning Framework (*see references for article source)*	**Article** on implementation suggestions for using EI and UDL in tandem to better support students access and understanding of lesson content with improved student engagement and demonstration of what they know and can do

Observation Tools

Resource	Description
NGSS Overview for Principals from NSTA.	This document will introduce principals to the Next Generation Science Standards (NGSS) and provide a brief and general overview of the key instructional and conceptual shifts. Principals will develop a better understanding of what an NGSS classroom should like today.
Instruction/practices: Conceptual Shifts in the Next Generation Science Standards	The following conceptual shifts in the NGSS highlight seven attributes to the conceptual shifts in NGSS standards that all administrators and teachers should become familiar with.
Walk-throughs for supervision and instruction in science	The Instructional Leadership for Science Practices (ILSP) tools are intended to support supervisors and teachers in evaluating and improving classroom instruction of science practices. The tools are organized in two sections: 1. Tools for Supervision, and 2. Tools for Instruction.
30-Minute Atlas Protocol	**Protocol** describing a collaborative process for examining students' performance data to inform next steps in teaching.

Evidence of Learning Tools

Resource	Description
30-Minute Atlas Protocol	**Protocol** describing a collaborative process for examining students' performance data to inform next steps in teaching.
Student Work Analysis Protocol	**Protocol** describing a process that groups of educators can use to discuss and analyze student work. It is intended to be applicable across subjects

Resource	Description
	and grades, including literacy, mathematics, science, the arts, and others. Analyzing student work gives educators information about students' understanding of concepts and skills and can help them make instructional decisions for improving student learning.
Calibration Protocol for Scoring Student Work	**Protocol** describing a process that groups of educators can use to discuss student work in order to reach consensus about how to score it based on rubric/scoring criteria. It is intended to be applicable across subjects and grades, including literacy, mathematics, science, the arts, and others. Examples of student work that can be used as practice for calibration are included as appendices.

Additional Tools and Resources

Resource	Description
School Reform Initiative (SRI)	**Website** with a wide range of protocols that support teaching and learning. The mission of the School Reform Initiative is to create transformational learning communities that are fiercely committed to educational equity and excellence.
National School Reform Faculty (NSRF)	**Website** with a wide range of protocols that can be used in collaborative settings, such as PLCs and Critical Friends groups, to enhance teaching and learning.
Sample Teaching Activities to Support Core Competencies of SEL	**Document** drawing on CASEL reviewed evidence-based programs to identify and describe some of the most common strategies used to promote student SEL.
Using Explicit and Systematic Instruction to Support Working Memory	**Article** with implementation examples in elementary expository text and mathematics lessons
Effective Practices Alignment Matrix	**Tool** describing Montana's Effective Practices Alignment Matrix of Three major national and statewide professional development initiatives: the Danielson Framework, Teaching Works High-leverage Practices (HLPs), and the Council for Exceptional Children HLPs for Students with Disabilities — using the effective practices ratings system developed by John C. Hattie.

Resource	Description
Collaborative Team Tool Kit	**Toolkit** from the State of New Jersey's Collaborative Teams intended to help schools establish productive collaborative teams of teachers and administrators working and learning together to help their students.
Questioning strategies to engage all learners	**Guide** to questioning strategies for teachers. Teachers strategically vary the types of questions they ask to generate meaningful dialog that supports the development of higher-order thinking skills.
Strategic Questioning	**Article** on strategic questioning. Strategic questioning is intentional, systematic and targets students' learning. Within such a process, students are not just listening and answering questions, but they are also involved in analyzing their teacher and peer's questions, raising more questions, taking turns to discuss each other's answers, and evaluating them.
Student Discourse	**Article** on six ways to move students' thinking to deeper understanding.
Visible Learning for Science: • Chapter 1: Science Learning Made Visible | Online Resources (corwin.com) • Chapter 2: Science Surface Learning Made Visible (corwin.com) • Chapter 3: Science Deep Learning Made Visible | Online Resources (corwin.com) • Chapter 4: Science Transfer Learning Made Visible | Online Resources (corwin.com) • Chapter 5: Science Learning made Visible Through Evaluation | Online Resources (corwin.com)	**Video** resources that support teachers in choosing the right strategy at the right time to scaffold learning for students.

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Section 4: High-Quality Learning Through Assessment

Introduction and Overview

As described in previous sections, the curriculum frameworks are built upon the foundation of rigorous standards and high-quality curriculum materials (HQCMs). Section 3 discussed how this foundation informs high-quality instruction. This section focuses on how it should also ensure high-quality learning through assessment. When properly designed and implemented, a comprehensive assessment system provides multiple perspectives and sources of data to help educators understand the full range of student achievement. Assessment information may be used to evaluate educational programs and practices and make informed decisions related to curriculum, instruction, intervention, professional learning, and the allocation of resources to better meet students' needs.

Assessment information also informs educators and families on student performance and their relationship to ongoing instructional practice. Various types of assessments are required because they provide different types of information regarding performance. A comprehensive assessment system must be appropriate for the student population and address the assessment needs of students at all grade levels, including those who speak languages other than English, are differently-abled, who struggle, or who excel. Most multilingual learners and differently-abled students participate in typical statewide and classroom-based assessment systems for science.

Student learning is most maximized with an aligned system of standards, curriculum, instruction, and assessment. When assessment is aligned with instruction, both students and teachers benefit. Students are more likely to learn because instruction is focused and because they are assessed on what they are taught. Teachers are also able to focus, making the best use of their time. Assessments are only useful if they provide information that is used to support and improve student learning.

Assessment inspires us to ask these hard questions:

- "Are we teaching what we think we are teaching?"
- "Are students learning what we want them to learn?"
- "Is there a way to teach the subject and student better, thereby promoting better learning?"

Section 4 will orient you to the purposes and types of assessment, the concepts of *validity*, *reliability*, and *fairness* in assessment, factors to consider when selecting or developing assessments, and considerations when assessing differently-abled students or multilingual learners.

Purposes and Types of Assessment

Assessment has an important and varied role in public education. Assessments are used to inform parents about their children's progress and overall achievement. Teachers use assessment to make decisions about instruction, assign grades, and determine eligibility for special services and program placement. They are used by evaluators to measure program and instructional effectiveness. They are also used to track progress toward school and LEA goals set by the state in accordance with federal regulations. When it comes to assessment of student learning, the why should precede the how because assessments should be designed and administered with the purpose in mind. The vast majority of assessments are used for one of three general purposes: to inform and improve instruction, to screen/identify (for interventions), and to measure outcomes.

When assessments are used to inform instruction, the data typically remain internal to the classroom. They are used to provide specific and ongoing information on a student's progress, strengths, and weaknesses, which can be used by teachers to plan and/or differentiate daily instruction. This daily process is most typically referred to as formative assessment. However, interim and summative assessments can also be used to impact instructional decision-making, though not in the short-cycle timeline that characterizes formative assessments. Assessments such as unit tests and even state assessment data can be used to reflect on and inform future instructional decisions.

When assessments are used to screen/identify, the data also typically remain internal to the school or LEA. Assessments that are used primarily to screen are administered to the total population of students and generally assess key skills that are indicators of students' larger skill set, rather than an in-depth analysis of the standards. They should be relatively quick to administer and easy to score. Assessments used for screening purposes can inform decisions about the placement of groups of students within an academic program structure or individual students' needs for academic interventions or special programs. When needed, screening assessments are followed by diagnostic assessments to determine if more targeted intervention is necessary or if a student has a disability.

Finally, when assessments are used to measure outcomes, data are communicated to parties external to the classroom. Whether it is a unit test that is entered into a grade book and communicated to parents or a standardized test that is reported to the State. Assessments used to measure outcomes attempt to measure what has been learned so that it can be quantified and reported. No single type of assessment, and certainly no single assessment, can serve all purposes.

From informal questioning to final exams, there are countless ways teachers may determine what students know, understand, and are able to do. The instruction cycle generally follows a pattern of determining where students are with respect to the standards being taught before instruction begins, monitoring their progress as the instruction unfolds, and then determining what knowledge and skills are learned as a result of instruction. Assessments, based on when they are administered relative to instruction, can be categorized as formative, summative, or interim.

The primary purpose of **formative assessment** is to inform instruction. As an instructional practice, it is described more fully in Section 3 of this framework. The Chief Council of State School Officers (CCSSO, 2018) updated its definition of formative assessment in 2021 and defines formative assessment in the following way:

Formative assessment is a planned, ongoing process used by all students and teachers during learning and teaching to elicit and use evidence of student learning to improve student understanding of intended disciplinary learning outcomes and support students to become self-directed learners.

Effective use of the formative assessment process requires students and teachers to integrate and embed the following practices in a collaborative and respectful classroom environment:

- *Clarifying learning goals and success criteria within a broader progression of learning;*
- *Eliciting and analyzing evidence of student thinking;*
- *Engaging in self-assessment and peer feedback;*
- *Providing actionable feedback; and*
- *Using evidence and feedback to move learning forward by adjusting learning strategies, goals, or next instructional steps.*

Additionally, formative assessment is integrated throughout instruction with the purpose of gathering evidence to adjust teaching, often in real time, to address student needs (Black and William, 2010), and capitalize on student strengths. There is ample evidence to support that this process produces "significant and often substantial learning gains" (Black and William, 2010) and these gains are often most pronounced for low-achieving students. Eliciting evidence of student thinking as part of the formative assessment process should take varied forms. Examples of strategies for gathering evidence of learning during the formative assessment process include exit slips, student checklists, one-sentence summaries, misconception checks (Alber, 2014), targeted questioning sequence, conferences, and observations.

Formative assessment becomes particularly powerful when it involves a component that allows for student self-assessment. When teachers clearly articulate learning goals, provide criteria for proficiency in meeting those goals, and orchestrate a classroom dialogue that unveils student understandings, students are then positioned to monitor their own learning. This self-knowledge, coupled with teacher support based on formative assessment data, can result in substantive learning gains (Black and William, 2010). Learner involvement in monitoring progress on their goals strengthens engagement for all students but is especially important for differently-abled students. Specific feedback comparing the students' achievement against the standard — rather than only against other students — increases personal performance. With specific feedback, learners should then have the opportunity to resubmit some items in response. Opportunities for students to monitor their own progress and make improvements based on specific feedback connect to the Social Emotional Learning competency of **Self-management** — learning to manage and express emotions appropriately, controlling impulses, overcoming challenges, setting goals, and persevering and Self-awareness Learning Standards 1B — I can identify when help is needed and who can provide it. **Self-Awareness** means students understand their areas of strength as well as areas of need. This skill is strengthened as they monitor their progress. By incorporating Universal Design for Learning guidelines, assessment feedback that is relevant, constructive, accessible, specific, and timely with a focus on moving the learner toward mastery is more productive in promoting engagement. The assessment process creates a continuous feedback loop, which systematically checks for progress and identifies strengths and weaknesses to improve learning gains during instruction.

Summative assessments are formal assessments that are given after a substantial block of instructional time, for example at the end of a unit, term course, or academic year. **Interim assessments** are administered during instruction and depending on the type of interim assessment can be used to screen students, inform instruction, or measure outcomes. By design and purpose, high-quality summative and interim assessments are less nimble in responding to student strengths and needs than formative assessments. They provide an overall picture of achievement and can be useful in predicting student outcomes/supports or evaluating the need for pedagogical or programmatic changes. These assessments should be written to include a variety of item types (e.g., selected response, constructed response, extended response, performance tasks) and represent the full scale of Webb's Depth of Knowledge (DOK). To maximize the potential for gathering concrete evidence of student learning as facilitated by curriculum and instruction, educators should routinely draw upon the assessments provided within their HQCMs (RIDE, 2012).

State assessments are summative assessments that are given annually and provide a valuable "snapshot" to educators and families and help us see how we are doing compared with other districts, compared with the state as a whole, and compared against several other high-performing states. State assessments only account for about 1 percent of most student's instructional time. Results from state assessments that are part of a comprehensive assessment system keep families and the public at large informed about school, district, and state achievement and progress.

Interim assessments include screeners and diagnostic assessments. Screening assessments are a type of interim assessment used as a first alert or indication of specific instructional need and are typically quick and easy to administer to a large number of students and easy to score. Assessments used for screening purposes can inform curriculum decisions about instruction for groups of students and for individual student's academic supports. Schools and districts often use interim assessments to screen and monitor student progress across the school year.

Examples of these assessments used in schools and districts include STAR, i-Ready, NWEA, IXL, and aimsweb. When needed, screening assessments can be followed by more intensive diagnostic assessments to determine if targeted interventions are necessary. Diagnostic assessments are often individually administered to students who have been identified through the screening process. The diagnostic assessments help to provide greater detail of the student's knowledge and skill.

Progress Monitoring	
General Outcome Measures (GOM)	GOMs measure automaticity of basic skills in reading, math, spelling and written expression as well as monitor readiness skills in literacy and numeracy. While GOMs do not measure all aspects of reading or math, they do serve as a predictive indicator of academic competence in these fundamental content areas and are typically used for setting intervention goals.
Mastery Measures	Mastery measures determine how much a student already knows about and where instruction should begin as well as determining when a student has mastered a particular skill taught. They help determine if the student is learning the specific skills as a result of an intervention and help identify where and how to intervene.

Performance assessments/tasks can be an effective way to assess students' learning of the standards within a high-quality curriculum. Performance assessments/tasks require students to apply understanding to complete a demonstration performance or product that can be judged on performance criteria (RIDE, 2012). Performance assessments can be designed to be formative, interim, or summative assessments of learning. They also allow for richer and more authentic assessment of learning. Educators can integrate performance assessments into instruction to provide additional learning experiences for students. Performance tasks are often included as one type of assessment in portfolios and exhibitions, such as those used as part of Rhode Island's Proficiency Based Graduation Requirements.

	Inform Instruction	Screen/Identify	Measure Outcomes
Summative	Generally, not used as the primary source of data to inform instruction. May be useful in examining program effectiveness.	Generally not used as the primary source of data to screen/identify students. May be one of multiple sources used.	Primary purpose is to measure outcomes (at classroom, school, LEA, or state level). Can be used for accountability, school improvement planning, evaluation, and research.
Formative	Primary purpose is to inform	Generally not used to	Generally not used to measure long term outcomes; rather, it is used to

	Inform Instruction	Screen/Identify	Measure Outcomes
	instruction.	screen/identify students.	measure whether students learned what was just taught before moving on to instructional "next steps". Evidence gathered as part of the formative assessment process may inform a referral to special education and may be used to help measure short-term objectives on IEPs.
Interim	May be used to inform instruction.	May be used to screen/identify students.	May be used to measure outcomes in a longer instructional sequence (e.g., end of a unit of study or quarter, semester, MTSS intervention goal, IEP goal). May be part of a special education referral.

As with summative and interim assessments, teachers should make use of the formative assessment options contained within their high-quality curriculum and use the Science Task Screen tools shared in the next section for validating.

Both formative and summative assessments can utilize strengths-based rubrics to provide critical feedback and allow for student self and/peer assessment as well as student growth goal setting aligned to specific criteria that needs to be met. The following aspects to high-quality rubric design come from the Sheridan Center, Brown University (Designing Grading Rubrics, 2021) and DePaul Teaching Commons (Rubrics, 2021):

- Start with the end in mind; what does an exemplar response look like?
- Use specific criteria aligned to the standards describing what students should know and do to meet the standards assessed.
- Refine the criteria for what approaching and exceeding the standard would include (use the NGSS Progressions Matrix for SEP's, CCC's, and DCI's). Language should be concrete and written with a strengths-based voice.
- The criteria should be observable and measurable.
- Use consistent language stems throughout.
- Assign a rating scale for each performance category.
- Provide space for written teacher feedback and a space for student reflection.
- For increased student growth over time, provide a space for students to set a goal for the revision or future assessments and learning.
- Norm your rubrics with collaborative scoring of student work and revise.
- Share your rubrics with students before assigning a task so they a clear on the expectations.
- Use of student exemplars for each level of performance with further support an increase in rigor of student responses.

What do educators need to know about validity, reliability and fairness?

Assessments must be designed and implemented to accurately collect student information. To do this they should all possess an optimal degree of

- *Validity* (the degree to which the assessment measures what it is supposed to measure — i.e., what is defined by the standards),

- *Reliability* (the consistency with which an assessment provides a picture of what a student knows and is able to do), and
- *Fairness* (lacks bias, is accessible, and is administered with equity) (RIDE, 2012).

In other words, within an assessment, the items must measure the standards or content. It is also critical that the assessment provide information that demonstrates an accurate reflection of student learning. Ensuring fairness is equally important within the assessment, particularly for differently-abled and multilingual learners, because lack of accessibility can impact validity. For example, an assessment may not measure what it was designed to measure if students cannot access the assessment items or stimuli due to linguistic barriers or inattention to other demonstrated learning needs.

One component of ensuring fairness is using assessments that are accessible to all students. Accessible assessment practices may include offering assessments in different modalities (e.g., Braille, oral) or languages, allowing students to respond in different modalities, or providing additional accommodations for students. Accessibility features are available for all students to ensure universal access to the assessment. To further support differently-abled students and multilingual learners, accommodations are also available on all state assessments. Accommodations refer to changes in setting, timing (including scheduling), presentation format, or response format that do not alter in any significant way what the test measures, or the comparability of the results. For example, reading a test aloud may be appropriate when a student is taking a history assessment, but would not be appropriate to assess a student's decoding ability. When used properly, accessibility features and appropriate test accommodations remove barriers to participation in the assessment and provide students with diverse learning needs an equitable opportunity to demonstrate their knowledge and skills.

To ensure language access for MLLs, universal accessibility features and accommodations can be leveraged during administration of assessments, in a manner consistent with Rhode Island State Assessment Program policy. For example, breaks and familiar test administrators are available to MLLs on all statewide assessments except Pre-SAT/SAT. For additional information about accessibility features, please see RIDE's Accommodations and Accessibility Features Manual. Accommodations are also available to MLLs on all statewide assessments. Examples of accommodations include bilingual dictionaries, reading aloud the test directions in the student's native language, and Spanish editions of math and science assessments. A full list of accommodations available to MLLs on each state assessment is available in RIDE's Accommodations and Accessibility Features Manual.

For both MLLs and DAS, assessment accommodations should reflect instructional accommodations used on a regular basis with a student. Educators evaluate the effectiveness of accommodations through data collection and the consideration of the following questions:

1. Did the student use the accommodation consistently?
2. Did the accommodation allow the student to access or demonstrate learning as well as his or her peers?
3. Did the accommodation allow the student to feel like a member of the class?
4. Did the student like using the accommodation?

Most students with IEPs participate in regular statewide assessments with accommodations as outlined in the IEP. DAS who receive testing accommodations must take the same statewide assessment as peers without IEPs. IEP team members collaborate to select accommodations based on educational needs demonstrated by current data, not based on placement or disability category. All students with disabilities should be included in educational accountability systems and a small percentage (~1%) of students with significant cognitive impairments participate in alternate state assessment. Educators should engage students and families in decisions about appropriate testing accommodations or participation in alternate assessments (i.e., DLM and Alternate ACCESS).

IDEA also speaks to accommodations on district assessments as well as statewide assessments. According to IDEA Sec. 300.320(a)(6), each child's IEP must include a statement of any individual appropriate accommodations that are necessary to measure the academic achievement and functional performance of the child on state **and districtwide assessments** consistent with section 612(a)(16) of the Act. When determining accommodations for district assessments, IEP teams, including the general educator, must consider the difference between target skills (the knowledge or skills being assessed) and access skills (needed to complete the assessment, but not specifically being measured) along with data on the strengths and needs of the individual student.

Another component for ensuring fairness is making sure the items do not include any bias in content or language that may disadvantage some students. For example, when assessing multilingual learners, it is important to use vocabulary that is widely accessible to students and avoid colloquial and idiomatic expressions and/or words with multiple meanings when it is not pertinent to what you are measuring. Whenever possible, use familiar contexts or objects like classroom or school experiences rather than ones that are outside of school that may or may not be familiar to all students. Keep sentence structures as simple as is possible while expressing the intended meaning.

Even with valid, reliable, and fair assessments, it is important for educators to consider multiple data points to ensure that they have a comprehensive understanding of student strengths and needs, especially when supporting DAS and MLLs. In addition to interim and diagnostic assessment, sources of information can range from observations, work samples, and curriculum-based measurement to functional behavioral assessments and parent input. These data points should be gathered within the core curriculum by general educators, rather than only by those providing specialized services, because data should guide daily decisions about instruction within general education. Multiple sources of information help educators collaborate to develop a comprehensive learner profile of strengths and needs. Educators can analyze the learning environment against that profile to identify necessary scaffolds and accommodations to remove barriers for DAS. Multiple sources of data are also important, seeing as language access can impact student data from content assessments in English.

Selecting and Developing Assessments

Building or refining a comprehensive assessment system begins by agreeing upon the purposes of the assessments the LEA will administer. One assessment cannot answer every question about student learning. Each type of assessment has a role in a comprehensive assessment system. The goal is not to have some — or enough — of each type; rather it is to understand that each type of assessment has a purpose and, when used effectively, can provide important information to further student learning. Some questions educator teams may ask themselves as part of any discussion of purpose include:

- "What do we want to know about student learning of the standards?"
- "What do we want to learn about students' skills and knowledge?"
- "What data do we need to answer those questions?"

Once claims and needs are identified, the appropriate assessments are selected to fulfill those data needs by asking: "Which assessment best serves our purpose?" For example, if a teacher wants to know if students learned the material just taught and identify where they may be struggling to adjust the next day's instruction, the teacher may give a short quiz which asks students a few questions targeting a specific skill. Whereas, if the teacher wanted to know if the students were proficient with the content taught during the first semester, the teacher may ask students to complete a longer test or performance task where students apply their new learning, thus measuring multiple standards/skills.

In addition to considering what purpose an assessment will serve, attention must be paid to the alignment of the assessment with the curriculum being used by the LEA. Curriculum materials embed assessments as part of the package provided to educators. In turn, educators must consider whether the assessments included meet the breadth of purposes and types needed for an assessment system that informs instruction and provides information about student learning. A good starting place is to review what assessments are available within the high-quality instructional materials, identify gaps and weaknesses, and develop a plan for which additional assessments may need to be purchased or developed. Remember any review of assessments needed involves a close use of the standards and universal design guidelines. Providing options in the way assessments are represented and allowing for students to demonstrate their understanding through multiple means of action and expression benefits all students, especially MLLs and DAS.

Assessments that are not adequately aligned with the LEA's adopted curriculum and universal design are not accurate indicators of student learning. This is especially important when assessment data are used in high-stakes decision-making, such as student promotion or graduation. Because every assessment has its limitations, it is preferable to use data from multiple assessments and types of assessments. By collecting data from multiple sources, one can feel more confident in inferences drawn from such data. When curriculum, instruction, and assessment are carefully aligned and working together, student learning is maximized.

Finally, when developing or selecting assessments, knowing whether an assessment is a good fit for your needs requires a basic understanding of item types and assessment methods and their respective features, advantages, and disadvantages. Though this is certainly not an exhaustive list, a few of the most common item types and assessment methods include selected response, constructed response, performance tasks, and observations/interviews. See *Comprehensive Assessment System: Rhode Island Criteria and Guidance (2012)* for a discussion of the advantages and disadvantages of each method.

Guidance tools for how to use the standards to design high-quality assessments in science

This section presents several tools, resources, and protocols for designing, validating, and collaboratively scoring performance assessments and tasks.

Designing

Districts need to know that designing and/or adapting assessments to NGSS is challenging. *A Framework for K-12 Education* (2012) call for three dimensionality within science instruction. Accordingly, assessing student knowledge will also require a three-dimensional approach to measure what students know and can do with respect to each performance expectation. In this section we present tools and resources to begin the process of ensuring your district is implementing a coherent high-quality assessment system.

- **NGSS Evidence Statements** are tools to help teachers and district leaders design three-dimensional assessment tasks for each performance expectation in the context of engaging in a science or engineering practice. These task formats represent different ways that assessment tasks and class investigations can be written to engage students in the science practices, https://www.nextgenscience.org/evidence-statements .

- For districts ready to engage in collaborative common assessment development, the *Nine Step Process to Designing a Three-Dimensional Assessment for Science (2021),* describes a proven backwards design structure while providing potential tasks and prompts to make the process complete and efficient; http://stemteachingtools.org/brief/29 .

- **Integrating Science Practices into Assessment Tasks,** *Stem Teaching Tool #30*. This detailed and flexible tool suggests activity formats to help teachers create three-dimensional assessments based on real-world science and engineering practices. http://stemteachingtools.org/assets/landscapes/STEM-Teaching-Tool-30-Task-Formats-for-3D-Assessment-Design-v2.pdf

- *Stem Teaching Tool* #65 provides guidance on using 3-dimensional NGSS interim assessments to support coherence, equity, and a shared understanding of learning, http://stemteachingtools.org/brief/65 .

- **How to design assessments for emerging bilingual students** - This tool will help to support multi-lingual learners while presenting inclusive strategies to the rich linguistic resources they bring to the classroom. This resource considers unpacking the language, translating assessment prompts, considerations for student response language, and leveraging what students already know, http://stemteachingtools.org/brief/33 .

Additional Resources for department heads, curriculum supervisors, instructional coaches, and principals for conducting your own professional learning opportunities in science assessment. All resources are OER and can be modified to fit your community's needs.

PD Resources (developed through the ACESSE Project):

- Session A: Introduction to Formative Assessment to Support Equitable 3D Instruction (60-70 minutes)
- Session B: How to Assess Three-Dimensional Learning in Your Classroom: Building Assessment Tasks that Work (60-70 minutes)
- Session C: Making Science Instruction Compelling for All Students: Using Cultural Formative Assessment to Build on Learner Interest and Experience

- Session D: How to Craft 3D Classroom Science Assessments
- Session E: Selecting Anchoring Phenomena for Equitable 3D Teaching
- Session G: Learning to See the Resources Students Bring to Sense-Making

Validating

The following two tools are intended to assist educators in evaluating science assessment tasks to determine whether they are designed for three-dimensional science standards based on the *Framework for K–12 Science Education*, such as the Next Generation Science Standards.

- The **Science Task Prescreen** can be used to conduct a quick review of assessment tasks to identify any "red flags" – challenges commonly found in science assessment tasks – and determine whether a task is worth diving into more deeply.
- The **Science Task Screener** is used to take that deeper dive into evaluating science assessment tasks. The purpose of the Science Task Screener is:
    1. to determine whether classroom assessment tasks are high-quality, designed to elicit evidence of three-dimensional performances, and designed to support the purpose for which they will be used; and
    2. to provide a group of reviewers with a common set of features to ground conversations about what it "looks like" for students to demonstrate the kinds of performances expected by three-dimensional standards. https://www.nextgenscience.org/taskscreener (2021)

Collaboratively Scoring

Data-driven protocols for analyzing student assessment data and student work:

- Student Work Analysis Protocol: https://www.ride.ri.gov/Portals/0/Uploads/Documents/Teachers-and-Administrators-Excellent-Educators/Educator-Evaluation/Online-Modules/Student_Work_Analysis_Protocol.pdf
- Collection of student work analysis protocols: https://curriculumsupport.org/wp-content/uploads/2018/12/Student-Work-Protocols.pdf
- Scoring Performance Tasks and Designing Instruction: Implementation strategies, calibration protocols, task revision and instructional implications. Educators will need to create a free account to access these powerful tools. https://www.performanceassessmentresourcebank.org/bin/implementation

High-quality Exemplar Assessment Items

- Educators will be able to browse by NGSS performance expectation and grade level, then download all materials necessary to implement. A collection of Short Performance Assessments can be accessed here: https://scienceeducation.stanford.edu/snap/assessments-ngss

- The *Task Annotation Project, TAPS* (2021), presents exemplars for each grade band. All items have gone through a rigorous design process and considerations for further improvements are provided for each item. They include: in
    - *Project-wide takeaways for educators, administrators, policy-makers, and assessment developers.*
    - *The "must-have" features of all three-dimensional science assessments.*
    - *Features of equitable science assessments.*
    - *Features of high-quality scenarios that drive three-dimensional assessments.*
    - *A practical definition of sense-making and its critical role in distinguishing three-dimensional assessments from more traditional science assessments.*
    - *Lessons-learned about how to assess science and engineering practices and crosscutting concepts.*

- *Implications for science assessment systems, including large-scale assessments, and recommendations for decision-makers involved in assessment design.* https://www.achieve.org/our-initiatives/equip/tools-subject/science/task-annotation-project-science (2021)

Assessment Considerations for MLLs and DAS

In addition to selecting and designing appropriate assessments, it is critical that educators use sound assessment practices to support MLLs and DAS during core instruction. Assessments offers valuable insight into MLL and DAS learning, and educators should use this data to plan and implement high-quality instruction. Through formative assessment, educators of science play a central role in providing feedback to MLLs on content and disciplinary language development and DAS on progress towards IEP goals.

As with academic content, a comprehensive assessment system is essential for monitoring the language development of MLLs. To assess English language proficiency, RIDE has adopted ACCESS for ELs as its statewide summative assessment. However, students cannot acquire a second language in a single block of the school day. Thus, it is imperative that educators and administrators develop systems for conducting ongoing formative assessments of content driven language instruction. This approach aligns to WIDA ELD Standards Framework as well as the Blueprint for MLL Success, both of which explicitly call for disciplinary language teaching within the core content areas.

The same integration of evidence-based assessment practices for DAS is needed within the general education curriculum. Seventy percent of RI students with IEPs are in general education settings at least 80% of their day. IEP goals are meant to measure and improve student progress *within* the general education curriculum. The specially-designed instruction is typically not happening separately, but in connection with the classroom instruction and curriculum. The general educator and special educator work in consultation to use classroom data to measure progress on an IEP goal along with any additional measures indicated in the IEP.

DAS may benefit from data-based individualization (DBI) to improve their progress in the general education curriculum. DBI is an iterative, problem-solving process that involves the analysis of progress-monitoring and diagnostic assessment data. Diagnostic data from tools such as standardized measures, error analysis of progress-monitoring data and work samples, or functional behavioral assessments (FBA) are collected and analyzed to identify the specific skill deficits that need to be targeted. The results of the diagnostic assessment, in combination with the teacher's analysis of what features of instruction need to be adjusted to better support the student, help staff determine how to individualize the student's instructional program to meet the individual student's unique needs and promote progress in the general education curriculum. The diagnostic process allows teachers to identify a student's specific area(s) of difficulty when lack of progress is evident and can inform decisions about how to adapt the intervention (National Center on Intensive Intervention, 2013).

Assessment to Support MLLs in High-Quality Core Instruction

The 2020 Edition of the WIDA ELD Standards Framework is different from previous iterations in that it contains proficiency level descriptors by grade level cluster to support developmentally appropriate, content-driven language learning. Educators of science should draw on these proficiency level descriptors to design or amplify formative assessments tracking MLLs' language development in science.

As with the formative assessment process in academic content, establishing clear learning goals is the first step in improving student understanding of intended content-based language outcomes. To use the proficiency level descriptors, educators must determine **the mode of communication** (i.e., whether they are assessing interpretative or expressive language) and select the corresponding set of descriptors. This determination will likely be made when the educator identifies the language goals. **Expressive language** refers to speaking, writing, and representing, whereas **interpretative language** includes listening, reading, and viewing.

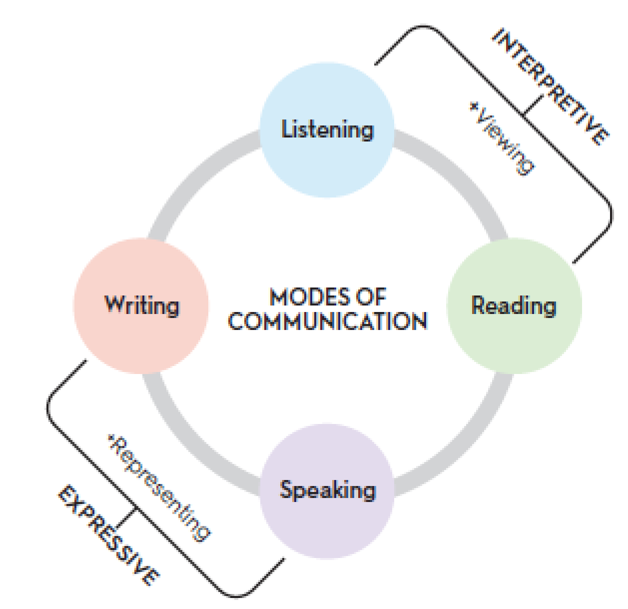

Image Source: 2020 Edition of WIDA ELD Standards Framework

The proficiency level descriptors should serve as a key resource to educators when refining language goals for assessment purposes, as the proficiency level descriptors highlight characteristics of language proficiency at each level. These descriptors are organized according to their discourse, sentence, and word dimensions. At the discourse level, as shown in the following table, the 2020 Edition distinguishes between language features that contribute to organization, cohesion, or density.

Grades 4-5 WIDA Proficiency Level Descriptors for the Expressive Communication Mode (Speaking, Writing, and Representing)

Toward the end of each proficiency level, when scaffolded appropriately, multilingual learners will...

Criteria	End of Level 1	End of Level 2	End of Level 3	End of Level 4	End of Level 5	Level 6
	Create coherent texts (spoken, written, multimodal) using...					
DISCOURSE Organization of language	short sentences linked by topic to convey an emerging sense of purpose (to inform, explain, argue, narrate)	sentences that convey intended purpose with emerging organization (topic sentence, supporting details)	short text that conveys intended purpose using predictable organizational patterns (signaled with some paragraph openers: *first, and then, then*)	expanding text that conveys intended purpose using generic (not genre-specific) organizational patterns across paragraphs (introduction, body, conclusion) with a variety of paragraph openers	text that conveys intended purpose using genre-specific organizational patterns (statement of position, arguments, call to action)	text that conveys intended purpose using genre-specific organizational patterns with strategic ways of signaling relationships between paragraphs and throughout text *(the first reason, the second reason, the evidence is...)*
	Connect ideas across a whole text through...					
DISCOURSE Cohesion of language	some frequently used cohesive devices (repetition, demonstratives)	some formulaic cohesive devices (pronoun referencing, etc.)	a growing number of cohesive devices (emerging use of articles to refer to the same word, synonyms, antonyms)	an expanding variety of cohesive devices (given/new, whole/part, class/subclass)	a flexible number of cohesive devices (substitution, ellipsis, given/new)	a wide variety of cohesive devices used in genre- and discipline-specific ways
	Elaborate or condense ideas through...					
DISCOURSE Density of language	a few types of elaboration (adding familiar adjectives to describe nouns: *maple syrup*)	some types of elaboration (adding newly learned or multiple adjectives to nouns *(thick, sweet, sticky maple syrup)*	a growing number of types of elaboration (adding articles or demonstratives to nouns: *the dark syrup*)	a variety of types of elaboration (adding in a variety of adjectives including concrete and abstract nouns: *the long, slow process...*)	a wide variety of types of elaboration (adding in embedded clauses after the noun: *the sap which boiled for six hours...*)	flexible range of types of elaboration that includes embedded clauses and condensed noun groups (elaborating: *a sweet sap that turned into a delicious syrup after hours of boiling* and condensing through nominalization: *this tedious process*)

Image Source: [2020 Edition of WIDA ELD Standards Framework]

During formative assessments, educators will not likely draw on all dimensions of language at once for assessment purposes. For instance, an exit ticket that asks students to produce two to three sentences would not be an appropriate language sample for assessing progress on organization of language. To adequately assess this discourse-level dimension of language, students would need authentic opportunities to demonstrate proficiency. An assessment item that calls for less than one paragraph or extended oral remarks, therefore, may not suffice for this purpose.

Rather than creating separate assessments to monitor progress towards disciplinary language development, educators should aim to augment assessments that are already part of their local core curricula. For example, multiple modalities could be incorporated into existing content assessments, allowing students to orally explain how they arrived at a particular solution or claim. This practice of amplifying existing materials with additional modalities aligns with UDL guidelines by providing multiple means of representations (perception, language, symbols) and multiple means for students to demonstrate their understanding (physical action, expression, and communication) — a critical design element for MLLs who need daily explicit speaking, listening, reading, and writing instruction.

Assessment to Support Differently-Abled Students in High-Quality Core Instruction

Differently-abled students are best supported when general and special educators use Universal Design for Learning (UDL) to collaboratively design and plan assessments aligned to clear learning goals to ensure they measure the intended goals of the learning experience. Flexibility in assessment options will support learners in demonstrating their knowledge. All learners can benefit from practice assessments, review guides, flexible timing, assistive technologies, or support resources and help reduce the barriers that do not change the learning goals being measured. In addition to improving access, flexible assessment options may decrease perceived threats or distractions so that learners can demonstrate their skills and knowledge. For example, a student with specific support needs for fine motor skills may be more able to participate in demonstrating knowledge of how to make a square when given the opportunity to drag and drop line segments in a technology tool rather than use a pencil on paper or a marker on a white board.

Educators can use high-leverage practices (HLPs) to leverage student learning across the content areas, grade levels, and various learner abilities. The HLPs contain specific evidence-based practices in four domains: Instruction, Assessment, Collaboration, and SEL.

High-leverage practice #6, on the use of student assessment data to analyze instructional practices and make necessary adjustments that improve student outcomes, highlights the importance of ongoing collaboration between general education and special education in this practice (McLeskey, J, 2017). Information from functional skills assessments, such as those provided by an occupational therapist or speech language therapist, can provide critical information for general educators to use when designing accessible assessments or discussing necessary accommodations to classroom and district assessments. When differently-abled students are not making the level of progress anticipated, the data-based individualization process is a diagnostic method that can help to improve the instructional experience and promote progress in the general education curriculum through a tiered continuum of interventions.

Resource	Description
High Leverage Practices Assessment Overview	Assessment plays a foundational role in special education. Students with disabilities are complex learners who have unique needs that exist alongside their strengths. This overview includes a summary of each HLP for assessment.
High-Leverage Practice (HLP) Leadership Guides from the Council for Exceptional Children	**Leadership Guides** for the following HLPs: #4 Use Multiple Sources of Information to Develop a Comprehensive Understanding of a Student’s Strengths and Needs #5 Interpret and Communicate Assessment Information with Stakeholders to Collaboratively Design and Implement Educational Programs #6 Use Student Assessment Data, Analyze Instructional Practices, and Make Necessary Adjustments that Improve Student Outcomes
Participate in Assessment IEP (promotingprogress.org)	This tip sheet provides information about participation in assessment and accommodations for assessments. It includes a brief summary of federal regulations and tips for implementation.
Accessibility & Accommodations for General Assessments | FAQ | NCEO	This online FAQ includes common questions and answers with hyperlinks to various resources on accessibility, accommodations, and modifications.

Resource	Description
IRIS | Page 3: Instructional Versus Testing Accommodations (vanderbilt.edu)	This online learning resource is a portion of an IRIS module that clarifies different types of accommodations.
DLM Assessments - Assessment - Instruction & Assessment World-Class - Rhode Island Department of Education (RIDE)	These documents and professional development modules, along with other relevant general education curriculum materials, may be used to inform instructional planning and goal-setting for students with significant cognitive impairments.
Differently-abled Multilingual Language Learners/ English Learners with Disabilities (ELSWD) The Role of Individualized Education Program (IEP) Teams and Participation in English Language Proficiency (ELP) Assessments	This document elaborates on federal guidance on the role of Individualized Education Program (IEP) teams and ELSWD participation in English Language Proficiency (ELP) assessments.
CAST | UDL Tips for Assessment	This resource provides quick tips and reflection questions to promote accessible assessment.
UDL: Increase mastery-oriented feedback (cast.org)	This component of the interactive UDL matrix supports educators in understanding the importance of accessible and meaningful feedback to students during the assessment process.
Universal Design of Assessments FAQ	NCEO online resource
Impact | Winter 2018/19 Volume 31, Number 2 | Together We Are Better! Collaborative Teaming to Support Authentic Inclusion of Students with Complex Support Needs Cheryl Jorgensen How-To (umn.edu)	In this article, figure 2 gives examples of using student work on a weekly basis to improve instruction and inclusion and monitor progress for a student with complex and intensive needs. Figures 3-4 provide specific support examples for the math case study.

Formative Assessment Resources

Resource	Description
Why Formative Assessments Matter	Introduction to the importance of formative assessments.
The Impact of Formative Assessment and Learning Intentions on Student Achievement	Summary of findings on formative assessment and student achievement.
CCSSO Revising the Definition of Formative Assessment	This resource provides an overview of the FAST SCASS's revised definition on formative assessment,

Resource	Description
	originally published in 2006. The revised definition includes an overview of the attributes of effective formative assessment and emphasizes new areas emerging from current research, theory, and practice.
Formative_Assessment_10_Key_Questions.pdf (wi.gov)	Consider using this document as one of a variety of resources to support educators' assessment literacy to build student-teacher relationships that improves student outcomes.
Focusing Formative Assessment on the Needs of English Language Learners	In this paper, we examine how formative assessment can enhance the teaching and learning of ELL students in particular.
Formative_Assessment_for_Students_with_Disabilities.pdf (ccsso.org)	This report provides both special education and general education teachers with an introduction to the knowledge and skills they need to confidently and successfully implement formative assessment for students with disabilities in their classrooms through text and video examples. The strategies described in this paper are not limited to use with differently-abled students and work for all students, including those with unfinished learning.

State Summative Assessment Resources

Resource Links
ACCESS for ELLs Alternate ACCESS for ELLs | WIDA (wisc.edu) DLM Assessments NAEP Assessments NGSA Assessments PSAT & SAT Assessments RICAS Assessments Rhode Island State Assessment Program (ri.gov) IEP Team Guidance on Eligibility for Alternate Assessments Assessment Accommodations - Assessment - Instruction & Assessment - Rhode Island Department of Education (ri.gov) DLM Assessments - Assessment - Instruction & Assessment World-Class - Rhode Island Department of Education (RIDE)

Additional Resources for a Comprehensive Assessment System

Resource Links
Determining Appropriateness of Assessment: Appendix B: EQUIP and Learning Forward Professional Learning Community Modules EQUIP Student Work Analysis Tool, SWAT EQUIP Annotated Student Work Initiative Rhode Island Proficiency Framework • Cross-Curricular • English Language Arts • Mathematics • Social Studies • Science Rhode Island Proficiency Framework: Scoring Criteria • ELA • Mathematics • Science • Social Studies Writing Calibration Writing Standards in Action

Screening

Types of Screening Resources	Description and Resource Links
Literacy/Dyslexia Screening	Universal literacy screening should be administered to all students to determine early risk of future reading difficulties. A preventative approach should be used to ensure student risk is revealed early on when intervention is most effective. If a student scores low on these screeners, additional assessments should be administered to determine a student's potential risk for dyslexia, a neurobiological weakness in phonological and orthographic processing. Screeners should include measures of Rapid Automatic Naming (RAN), phonemic awareness, real and pseudoword reading, as well as vocabulary and syntactic awareness, which have implications on prosody, fluency, and ultimately comprehension. For additional guidance, including screening guidance by grade, please see the Massachusetts Dyslexia Guidelines
Early Childhood Screening	Child Outreach is Rhode Island's universal developmental screening system designed to screen all children ages 3 to 5 annually, prior to kindergarten entry. Developmental screenings sample developmental tasks in a wide range of areas and have been designed to determine whether a child may experience a challenge that will interfere with the

Types of Screening Resources	Description and Resource Links
	acquisition of knowledge or skills. Screening results are often the first step in identifying children who may need further assessment, intervention, and/or services at an early age to promote positive outcomes in kindergarten and beyond. Child Outreach Screening - Early Childhood Special Education - Early Childhood - Instruction & Assessment - Rhode Island Department of Education (ri.gov)
MLL Screening	Screening for MLL identification involves completion of the state-approved Home Language Survey (HLS) and potential administration of a Language Screening Assessment, based on responses to the HLS. The guidance below outlines the state-adopted procedure for identifying English Learners in accordance with statue R.I.G.L.16-54-3 and regulation 200-RICR-20-30-3. Additional information on federal and state requirements for screening MLLs can be found in the assessment and placement section of the MLL Toolkit. Multilingual Learner (MLL) Identification, Screening, Placement and Reclassification (May 2021)
Universal Academic Screening	Through universal academic screening, school teams systematically and regularly analyze schoolwide data to determine the health of core instruction. Current academic performance levels from a screener are one type of academic data teams use to identify strengths and areas of need at a grade level as part of a MTSS. Screening within an MTSS Framework Educator Resources for high quality interim assessments Interim Assessments - Assessment - Instruction & Assessment World-Class - Rhode Island Department of Education (RIDE) Assessment Practices Within a Multi-Tiered System of Supports (ufl.edu) Bailey, T. R., Colpo, A. & Foley, A. (2020). Assessment Practices Within a Multi-Tiered System of Supports (Document No. IC-18). Retrieved from University of Florida, Collaboration for Effective Educator, Development, Accountability, and Reform Center website: https://ceedar.education.ufl.edu/innovation-configurations/

Diagnostic

Resource	Description
IEP Tip Sheet: Measuring Progress Toward Annual Goals | Progress Center (promotingprogress.org)	Suggestions for what to do and what to avoid when **designing progress monitoring plans** for differently-abled students plus additional resources to learn more.
Student Progress Monitoring Tool for Data Collection and Graphing (Excel) | National Center on Intensive Intervention	This Excel tool is designed to help educators **collect academic progress monitoring data** across multiple measures as a part of the data-based individualization (DBI) process. This tool allows educators to store data for

Resource	Description
	multiple students (across multiple measures), graph student progress, and set individualized goals for a student on specific measures.
Progress Center High-Quality Academic IEP Program Goals	Recorded **webinar, resources, and materials** on how to set ambitious goals for students by selecting a valid, reliable progress monitoring measure, establishing baseline performance, choosing a strategy, and writing a measurable goal.
Student-Level Data-Based Individualization Implementation Checklists (intensiveintervention.org)	Teams can use these **checklists to monitor** implementation of the data-based individualization (DBI) process during initial planning and ongoing review (progress monitoring) meetings.
Tools to Support Intensive Intervention Data Meetings | National Center on Intensive Intervention (NCII)	NCII has created a **series of tools** to help teams establish **efficient and effective** individual student **data meetings.** In the DBI process, the team is focused on the needs of individual students who are not making progress in their current intervention or special education program.
Data Collection and Analysis for Continuous Improvement	Collection and analysis of progress monitoring data are necessary for understanding how students are progressing towards their IEP goals. These data, along with other data sources, can support ongoing instructional decision making across the continuum of supports and assist teams in evaluating the effectiveness of IEP implementation. In the Data Collection and Analysis for Continuous Improvement menu are **resources and tools for progress monitoring math and reading, selecting tools, and keeping an implementation log.**
Toolkit_Student-Progress-Monitoring.pdf (transitionta.org)	The National Technical Assistance Center on Transition (NTACT) **toolkit supports data-driven decision-making** for middle and high school students to connect their academic progress and transition goals — includes 50-plus pages of sample tools. Note the inventory on reading, writing, presenting, and study habits (pp. 48–49), and the small group direction instruction recording sheet (p. 71).
The 5 Steps of Data-Based Individualization	From the Progress Center, educators can build knowledge of the data-based individualization (DBI) process that is used to support a **diagnostic practice** and improve instruction for students with intensive learning needs.

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