OpenSciEd Elementary Teacher Handbook

DRAFT

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OpenSciEd

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Contents

Vision for OpenSciEd Elementary

Young people are curious by nature--the whole world is a new and interesting place to explore and ask questions about, and kids have lots of questions! In OpenSciEd Elementary, we envision classrooms where students' natural curiosities about the world are leveraged to motivate their learning in science. Meaningful learning in science begins with student ideas and questions about how something in the world works. As young scientists, the students can then explore their questions through various sensemaking activities, such as investigations, discussions, and developing models to explain natural phenomena. Students can draw upon the rich resources of their own experiences and knowledge in their families and communities to make progress on their scientific questions. They can also draw on what they find out through informational text, images, and other multimedia explorations. Our hope for OpenSciEd Elementary is to provide a way to learn and do science that values who students are, centers the ideas students bring to the classroom, and fosters learning that is authentic to the practices of science while helping students to explain and better the world they experience every day.

About the Teacher Handbook

The OpenSciEd Project is a revolutionary effort to implement the recommendations of the National Research Council in its 2012 Framework for K–12 Science Education (National Research Council, 2012), as embodied in the science standards of the more than 35 states that have used the NRC Framework and the Next Generation Science Standards (NGSS Lead States, 2013) to inform their local standards. The objective of the OpenSciEd Project is to create and disseminate instructional materials that implement the approach to science teaching and learning that has come to be known as three-dimensional science learning since the release of these documents.

While the OpenSciEd units are designed to provide teachers who are new to three-dimensional learning with enough support to implement the units successfully, this OpenSciEd Teacher Handbook provides overviews of features of the OpenSciEd units that are likely to be new to many teachers. Each chapter focuses on a different feature. It is not designed to be read from front to back. We envision that teachers will read some chapters as an introduction to the OpenSciEd approach as they begin to plan for instruction, and will choose to read others on an as-needed basis as they go through the planning process. Most importantly, the Handbook is designed to be a resource that teachers can refer back to at any time. Ultimately, we believe that teachers learn new practices by doing--through the acts of planning, implementing, reflecting, and replanning. We envision this Handbook as one support for that learning-by-doing process, ideally in combination with other informational resources, peers, and experts.

For specific strategies to support all learners in using OpenSciEd materials, please see the Additional Accessibility Resources document.

The OpenSciEd Instructional Approach for Elementary

OpenSciEd units are designed using a form of "science storyline" approach. The goal of a science storyline approach is to provide students with a meaningful experience that is motivated by the students' own desires to explain something they don't understand or to solve a problem their classroom has come to care about (Reiser, Novak, & McGill, 2017). We use the metaphor of a storyline to capture the fact that learners should be motivated to work through the next puzzle in their science investigations just as they are motivated to see what happens next in an unfolding story.

An OpenSciEd unit storyline is a logical sequence of lessons that are motivated by students' questions. It is a science storyline because the questions arise from students' interactions with phenomena. OpenSciEd storylines are designed to provide students with the goal of explaining a phenomenon and/or solving a problem. Each step is designed to enable students to make progress on their questions by using science and engineering practices to help figure out a piece of a science idea. Each piece they figure out adds to the developing explanation, model, or design solution. Each step may also generate new questions that add to students' work in the storyline. As a step-wise process of questioning, investigating, and building understanding, a storyline provides a coherent path toward building a disciplinary core idea and crosscutting concepts, anchored in students' own experiences and questions.

Why use science storylines to organize OpenSciEd units?

In traditional approaches to science teaching, units are sequenced based on how experts understand the relationship among concepts. This means that it typically requires an understanding of the concepts being taught to understand why a unit is sequenced the way it is. The result is that the sequence of activities may make sense to a teacher, but doesn't necessarily make sense to the students. For example, a teacher may understand how certain activities to learn about plants will help students understand important life cycle concepts, but students may only know that they are learning about plants because their teacher told them they were going to grow plants. Or a teacher may know how a particular force experiment demonstrates something about opposing forces, but the only reason her students may have for doing that experiment is that it is part of their assignment from the teacher.

In the OpenSciEd storyline approach, the sequence of activities is designed to make sense to students. We call that "coherence from the students' perspective." When a storyline is coherent from the students' perspective, a visitor to the classroom on any given day should be able to walk over to a group of students, ask why they're working on that right now, and receive an answer that describes a question they are trying to figure out or a problem they are trying to solve.

There are four key considerations in the OpenSciEd instructional approach:

- Phenomena
- Disciplinary Core Ideas
- Science and Engineering Practices
- Crosscutting Concepts

The disciplinary core ideas, science and engineering practices, and crosscutting concepts reflect the *Framework for K–12 Science Education* and the performance expectations embodied by the Next Generation Science Standards and the standards of the more than 35 states that have used these documents to inform their state science standards.

What is the role of phenomena in OpenSciEd?

Interesting phenomena are key to the OpenSciEd storyline approach. Ultimately, every storyline is a journey to figuring out a phenomenon that defies easy explanation. It might be a surprising or puzzling phenomenon or something that violates the rules of the world that students have come to accept, like an object that levitates. It might be a phenomenon that students need to understand to address a problem, such as predicting and preparing for a violent storm. It might be a phenomenon that they want to know how to control, like soil erosion on a farm. Or, it might be an everyday phenomenon that mystifies students when they stop to think about it, like how puppies kind of do but kind of don't look like adult dogs.

In OpenSciEd units, phenomena are carefully selected to anchor a storyline and to motivate the development of target disciplinary core ideas, crosscutting concepts, and science and engineering practices. These anchoring phenomena are used to draw students into the storyline by presenting the natural challenge of explaining something or solving a problem. Other phenomena may be introduced at key points in a storyline to maintain interest or push students to delve more deeply.

What is the role of the disciplinary core ideas in OpenSciEd?

In OpenSciEd, students use disciplinary core ideas (DCIs) to make sense of how and why phenomena occur. OpenSciEd units are designed to help young students draw upon their everyday experiences of the world, but then extend that learning to build new science knowledge. OpenSciEd lessons call out which elements of the DCIs are targeted in each lesson and identify new aspects of these ideas that students begin to develop in the lesson. The unit overview and teacher background sections for each unit explain the progression through which DCIs are incrementally developed and extended in the unit. The OpenSciEd Scope and Sequence provides a pathway through which students can coherently build the target DCIs across elementary school, drawing on and revising ideas built in prior units.

What is the role of the science and engineering practices in OpenSciEd?

In OpenSciEd, science and engineering practices (SEPs) provide the avenue by which students develop new ideas and make new discoveries throughout the storyline. Students use questioning to articulate what they need to figure out. They investigate to generate new ideas about why things work the way they do or to test their conjectures. They construct models and explanations to organize their ideas and share them with others. Science and engineering practices guide the work with phenomena and problems so students can develop, test, and refine science ideas. In the primary grades, the science and engineering practices are explicitly introduced to students through both texts and repeated opportunities to practice. In grades 3-5, students expand their knowledge of science and engineering practices, and they continue to increase their understanding of how those practices support their learning in science.

What is the role of the crosscutting concepts in OpenSciEd?

In OpenSciEd units, the crosscutting concepts (CCCs) are used to support student sensemaking in three general ways:

- by providing a scaffold to ask productive and/or investigable questions
- as a set of principles and heuristics to guide model building and explanation
- as a way to frame the sequence of students' experiences of related phenomena in ways that engage students in analogical reasoning

The CCCs are developed and used strategically to help students make connections within and across units. Use of CCCs in grades K-5 involves an intentional transition from highly scaffolded experiences with CCCs applied to curated phenomena to fewer explicit supports for students, encouraging them to draw upon the CCCs and apply them to phenomena they experience on their own.

The Importance of the Three Dimensions in a Storyline

Each OpenSciEd unit is anchored in a phenomenon or set of phenomena and strategically integrates the DCIs, SEPs, and CCCs to create a storyline path in which the students and teachers, as a learning community, work together to manage the trajectory of their knowledge-building. The class, as a whole, incrementally develops ideas over time that are motivated by questions about phenomena in the world, where each step is an attempt to address a question or a gap in the class's current explanatory model, while developing, using, and extending parts of the DCIs, SEPs, and CCCs as needed. The storyline approach supports students' agency in sensemaking: WE figure out the science ideas and WE put those ideas together over time.

Summary of OpenSciEd Instructional Elements

Element	Description
Phenomena Based Centered around figuring out phenomena or solving problems	• Students' work is anchored in meaningful phenomena or problems that motivate building ideas over time. • Anchoring phenomena and problems are complex, relevant, and revisited as students figure out more. • Students investigate related phenomena to figure out pieces of the explanation. • In older grades, assessments ask students to make sense of specific and compelling phenomena using the understandings they built during the unit.
Coherent for Students Driven by students' questions and ideas	• Students' prior ideas and understandings are elicited, valued, and built upon. • Students and teachers work together to figure out where to go next and what evidence is needed to answer their questions. • Students understand what they are doing and how it will help them answer questions about a larger phenomenon or solve a problem. • Students engage in science and engineering practices in meaningful ways to make progress on their questions.
Driven by Evidence Incremental building and revision of ideas based on evidence	• Students' ideas and questions determine what evidence to collect. • Students seek and use evidence to figure something out as they build and revise their explanations, models, and arguments. • Investigations provide evidence to build new science ideas instead of confirming pre-taught ideas. • Evidence can be used to problematize students' current thinking and help them think about where to go next.
Collaborative WE figure out ideas together	• Students have opportunities to use, build upon, and critique others' ideas. • Students use evidence to support ideas, ask for evidence from others, and suggest ways to get additional evidence. • Students have several opportunities to give and receive feedback. • The culture of the classroom supports risk-taking and changing our minds.

Equitable Requires a classroom culture that values all ideas	• Students have multiple opportunities to make sense individually and through small and whole group discussions. • The class community values the diversity of resources students bring to science class, including language, gestures, metaphors, and various modes of expression. • Classroom agreements are established and revisited to support equitable sensemaking. • Teachers integrate a variety of assessment activities to elicit, interpret, and provide feedback to build from students' diverse ideas and experiences. • Students understand how and why what they are learning is relevant to their own lives and their communities.

Portions of this section are adapted from tools and processes developed by NextGen Science Storylines at Northwestern University and from the Next Generation Science Exemplar System Project (NGSX) at Clark University and Tidemark Institute. The work of NextGen Science Storylines was funded by support from the Gordon and Betty Moore Foundation, the James S. McDonnell Foundation, and the Carnegie Corporation of NY to Northwestern University; the William and Flora Hewlett Foundation to the University of Colorado, Boulder; and support from the NGSX Project at Clark University, Tidemark Institute, and Northwestern University.

OpenSciEd Instructional Model

OpenSciEd units are structured around the OpenSciEd instructional model for elementary schools which includes three types of lessons, and each lesson consists of four components.

What is a lesson in OpenSciEd?

It is commonplace to use the term *lesson* to describe the plan for that day's instruction. For many teachers, a lesson equals one class period. But, elementary schools have very different structures and minutes allocated for science. A science class period for one teacher might be 20 minutes every day, but for another teacher it might be 40 minutes, three times per week or even 60 minutes on Fridays. For that reason, OpenSciEd units use 'lesson' in a different way. A lesson within an OpenSciEd unit is a set of instructional time focused on answering a lesson question or figuring out something about a phenomenon. This may take multiple class periods or days of instruction. OpenSciEd lessons typically last 60 minutes in grades K-2 and 90 minutes in grades 3-5, with some exceptions (noted in the teacher guides). It is up to the teacher to decide how to "chunk" that time into their unique schedule, and lessons are structured using components to support this distribution of science instructional time over school days and weeks. We have provided a planning tool in Appendix A that teachers can use to figure out how to teach OpenSciEd lessons across their allocated science time and other parts of the school day.

How many instructional minutes are planned in the OpenSciEd Elementary program?

Grade	Unit 1	Unit 2	Unit 3	Unit 4	Total
K	10 lessons 600 minutes	10 lessons 600 minutes	10 lessons 600 minutes	10 lessons 600 minutes	2,400 minutes
1	10 lessons 600 minutes	10 lessons 600 minutes	10 lessons 600 minutes	10 lessons 600 minutes	2,400 minutes
2	10 lessons 600 minutes	10 lessons 600 minutes	10 lessons 600 minutes	10 lessons 600 minutes	2,400 minutes
3	14 lessons 1,260 minutes	12 lessons 1,080 minutes	14 lessons 1,260 minutes	TBD lessons TBD minutes	No more than 5,400 minutes
4	12 lessons 1,080 minutes	14 lessons 1,260 minutes	14 lessons 1,260 minutes	TBD lessons TBD minutes	No more than 5,400 minutes
5	15 lessons 1,350 minutes	15 lessons 1,350 minutes	13 lessons 1,170 minutes	TBD lessons TBD minutes	No more than 5,400 minutes

Types of Lessons

Anchoring Phenomenon Lesson

What is the purpose of this lesson type?

An Anchoring Phenomenon Lesson kicks off each unit of study and drives student motivation throughout the unit. The purpose of the Anchoring Phenomenon Lesson is to build a shared mission for a learning community that motivates students in figuring out phenomena or solving design problems. More specifically, the Anchoring Phenomenon Lesson serves to ground student learning in a common experience and then use that experience to elicit and feed students' curiosity, which will drive learning throughout the unit. The Anchoring Phenomenon Lesson also serves as a critical time to capture students' initial ideas as a pre-assessment opportunity.

An Anchoring Phenomenon Lesson

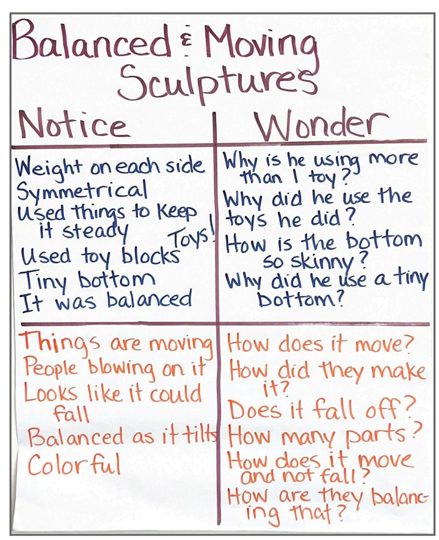
- introduces the phenomenon;
- creates an opportunity for students to share their initial ideas about the phenomenon;
- identifies the areas of agreement and disagreement in students' ideas about how or why aspects of the phenomenon occur;
- exposes to the teacher what students do and do not yet know about the phenomenon; and
- elicits questions that the students want to investigate and answer throughout the unit, which the teacher will be able to use to motivate students and connect the lessons in the unit.

When is it done within a unit?

An Anchoring Phenomenon Lesson is the first lesson in each unit. There are some units that also use this type of lesson in the middle of the unit to re-anchor with a related phenomenon.

How do students typically share their thinking in an Anchoring Phenomenon Lesson?

Students express their initial ideas by talking and gesturing, drawing, and writing. The Anchoring Phenomenon Lesson provides opportunities for students to represent their thinking, individually and collectively, by developing initial models, explanations, and/or design solutions. In the Anchoring Phenomenon Lesson, students make their questions public in some way, such as on a Notice and Wonder chart or a Driving Question Board, and generate ideas for potential investigations.



Investigation Lesson

What is the purpose of this lesson type?

Investigation Lessons use questions around a phenomenon (the unit's anchoring phenomenon and/or other related phenomena) that lead the class to engage in science practices to make sense of the phenomenon, and then develop the science ideas as part of the explanation. This is the basic structure of the work of three-dimensional learning: Gather information and evidence from investigations and connections to figure out ideas about phenomena or design problems.

In Investigation Lessons, students may

- Work with their class to create a plan of action.
- Engage in science and engineering practices.
- Make sense of what they figured out.

When is it done within a unit?

Investigation Lessons are the most common lesson type and happen throughout the unit.

How do students typically share their thinking in Investigation Lessons?

Investigation Lessons encourage students to talk, gesture, draw, and write to share their thinking. Students work with partners, with small groups, as a class, and sometimes individually, and may express and represent their individual or collective thinking in many different ways, including these:

- Plan an investigation or physical model to test.
- Record observations and measurements.
- Organize and analyze data.
- Examine evidence.
- Articulate new ideas and compare them to current models.
- Revise models.
- Ask additional questions and make predictions.

Putting Pieces Together Lesson

What is the purpose of this lesson type?

In the Putting Pieces Together Lesson, students take the pieces of ideas they have developed across multiple investigations and figure out how they can be connected to account for the phenomenon or how they work to solve the problem the class has identified. This lesson type provides an opportunity for students to take stock of their learning and work as a class to develop a fuller explanation, a consensus model, a design solution, or a plan for sharing the ideas they have built in the unit. Sometimes students have the opportunity to apply their ideas to explain another related phenomenon. Putting Pieces Together Lessons generally include opportunities for summative assessment.

When is it done within a unit?

Putting Pieces Together Lessons happen at the end of the unit. Some units also include a Putting Pieces Together Lesson at a significant midpoint in the unit.

How do students typically share their thinking in a Putting Pieces Together Lesson?

The class works together (talking, gesturing, drawing, writing) in a Putting Pieces Together Lesson to construct one or more of the following representations of their collective thinking:

- a final consensus model or explanation
- an accounting of the answers to questions they had on their Driving Question Board
- a Gotta-Have-It Checklist of the key ideas they figured out
- an optimized design solution
- a way to share their ideas with the community beyond their classroom

Students may also work independently to represent or express their individual explanations of a related phenomenon by creating a model, a page in a class book, a piece for an art fair, a poster to share with the school, a letter or video to a trusted adult, etc. Depending on the students' ages, independent work like this might happen over the course of one or more lessons.

Components Within Lessons

What are lesson components?

Lessons are composed of the following components: Navigate, Explore, Connect, and Synthesize. These components are distinct “chunks” of the lesson with different purposes (see below). A lesson may repeat some components (such as beginning and ending with Navigate), and occasionally lessons do not include all four components. The components in each lesson are arranged in a specific order to support the work students do to figure out and make sense of science ideas. Therefore, **teachers should teach the components in the order they are included in the lesson’s teacher guide and complete all components in a lesson before moving on to the next lesson.**

What is the purpose of lesson components?

Composing lessons of these components supports teachers in 1) understanding the instructional elements and purpose of the lesson, and 2) scheduling time for science.

1. As explained below, the four components each serve a different purpose, each of which is critical to the OpenSciEd instructional model. Clearly identifying the components of each lesson helps the teacher see what the class will be doing in each part to develop their science ideas, often while using literacy, math, and community-building practices as well.
2. The lesson components provide a way to accommodate the myriad ways schools and classrooms make time for science. Since schedules vary, having a lesson already divided into manageable chunks helps teachers plan how to distribute the work of the lesson across their school day and week. (See the sample planning tools in Appendix A, and each unit includes a sample pacing calendar in the front matter.) The “Learning Plan Snapshot” at the beginning of each lesson’s teacher guide briefly lays out the components of that lesson so teachers can decide which pieces of the lesson can happen during science time and which might fit into other parts of their school day, such as morning meeting or read aloud. That said, recall that the **components should be taught in the order they appear in each lesson**, even as they could be distributed across a day.

Navigate Component

What is the instructional purpose of this component?

The Navigate component directly supports coherence for students from lesson to lesson. This component generally happens at the beginning and end of each lesson and provides opportunities for the class to take stock of where they are in finding answers to their questions, remind themselves what they figured out last time, and decide where they want to go next. Often this navigation will come naturally from questions generated by students, but occasionally the teacher will “problematize” an idea or investigation result by asking a salient question or pushing the class to consider other situations or new directions.

What are the potential outcomes of this component?
During the Navigate component, students ask questions, define problems, and make predictions. The class builds their sense of shared purpose, sees progress toward answering their questions, and takes ownership of their science work.

Explore Component

What is the instructional purpose of this component?
The purpose of the Explore component is to have students gather data and information from their own investigations or work with data from investigations others have done. The Explore component always happens in Anchoring Phenomenon Lessons and Investigation Lessons, and occasionally happens in Putting Pieces Together Lessons.

What are the potential outcomes of this component?
In the Explore component, students may collaboratively create plans for investigations and carry them out to produce data. Students may build and test potential design solutions. They analyze and interpret data from their investigations or from investigations others have done to use as evidence to support the science ideas they are developing. The Explore component often provides authentic opportunities to use mathematics and computational thinking as students record observations and organize and analyze data.

Connect Component

What is the instructional purpose of this component?
The Connect component serves to bring ideas in from beyond the classroom and provides opportunities for sharing what students have figured out with others. This component supports students in seeing how their science work connects to the “real world”, and helps students develop expansive ideas of what it means to “do science” (i.e., who does science, how, and for what purposes) in order to see themselves as scientists and engineers. The Connect component happens in almost every lesson in the unit.

What are the potential outcomes of this component?
Students obtain, evaluate, and communicate information during the Connect component by making connections to their own lived experiences using community tours, interactive read alouds, videos, interviews, articles, letters, podcasts, etc. Students identify related phenomena to investigate and broaden the application of ideas and explanations they are developing. Students build understandings about how what they are figuring out has impacted plants and animals (including humans) and how others outside of the classroom have explored similar phenomena, possibly in different ways.

Synthesize Component

What is the instructional purpose of this component?

The Synthesize component is where students make sense of what they figured out in the lesson, answering questions such as "How does this all make sense together?" and "How does today's work help us explain our anchoring phenomenon?". The students build understandings of science ideas based on the work of that lesson and consider how those ideas help them make progress on the shared mission of the unit.

What are the potential outcomes of this component?

In the Synthesize component, students often develop and use models, construct explanations, or design solutions. They frequently engage in argument from evidence as they discuss the ideas they are building.

Example Components by Lesson Type

Recall that components may occur in any order (though Navigate is usually at the beginning and end), components may be repeated within a lesson, and not all lessons always include each component.

Anchoring Phenomenon Lesson	Investigation Lesson	Putting Pieces Together Lesson
Explore	Navigate	Navigate
Connect	Explore	Connect
Synthesize	Connect	(Explore?)
Navigate	Synthesize	Synthesize
	Navigate	(Navigate?)

Structure of OpenSciEd Elementary Materials

What unit-wide materials are available?

Unit Front Matter

The front matter of the unit includes important overview information for the unit, including the following sections.

- What is the anchoring phenomenon and why was it chosen?
- What Performance Expectations does the unit address?
- Which SEPs, DCIs, and CCCs are intentionally developed and practiced in the unit?
- Where does the unit fall in the scope and sequence? What if I teach it out of sequence?
- What ideas and experiences will students bring that can help them in this unit?
- What literacy and math connections and supports does this unit include?
- What strategies are important for supporting equitable science learning in this unit?
- How can I fit this unit's lessons into my school schedule?
- Vocabulary Guidance
- Safety Information

Unit Storyline

The storyline for each unit shows lesson-by-lesson what students will investigate, how they will work to answer their questions, what they will figure out, and how each lesson is connected to the next.

About the Science

This document explains the science ideas students will figure out in the unit, and also describes the boundaries of those ideas. Resources are listed for adult-level learning about the science concepts in the unit.

Assessment System Overview

The Assessment System Overview includes two tables: one lists the assessment opportunities in the unit by type (with links to the relevant student and teacher materials), and the other describes the assessment opportunities in the unit lesson-by-lesson.

SEP-CCC-DCI-ELA-Math Matrix

This resource gives lesson-level details about how specific elements and CCSS standards are used throughout the unit, divided into the following sections.

- Alignment with the Three Dimensions of NGSS: SEPs, CCCs, and DCIs
- Unit Connections to the Common Core Standards: English Language Arts
- Unit Connections to the Common Core Standards: Math

What are the SEP, DCI, and CCC codes?

Each unit includes a set of matrices indicating the elements of science and engineering practices (SEPs), disciplinary core ideas (DCIs), and crosscutting concepts (CCCs) developed and practiced in the unit.

The codes used in the SEP and CCC matrices come from *The NSTA Atlas of the Three Dimensions* (Willard, 2020) and follow this pattern:

- The letter code indicates the SEP or CCC from the lists below.
- "P" stands for "primary" (K-2) and "E" stands for "elementary" (grades 3-5).
- The second number indicates the bulleted idea (or "element") from the tables in NGSS Appendix F and Appendix G.

For example, the SEP code **AQDP-E2** refers to Asking Questions and Defining Problems, grades 3-5, element 2 (the second bulleted statement in the list in Appendix F, also shown here).

Grades 3-5
Asking questions and defining problems in 3–5 builds on K–2 experiences and progresses to specifying qualitative relationships. • Ask questions about what would happen if a variable is changed. • Identify scientific (testable) and non-scientific (non-testable) questions. • Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships. • Use prior knowledge to describe problems that can be solved. • Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost.

Science and Engineering Practices		Crosscutting Concepts	
AQDP	Asking Questions and Defining Problems	PAT	Patterns
MOD	Developing and Using Models	CE	Cause and Effect
INV	Planning and Carrying Out Investigations	SPQ	Scale, Proportion, and Quantity
DATA	Analyzing and Interpreting Data	SYS	Systems and System Models
MATH	Using Mathematics and Computational Thinking	EM	Energy and Matter
CEDS	Constructing Explanations and Designing Solutions	SF	Structure and Function
ARG	Engaging in Argument from Evidence	SC	Stability and Change
INFO	Obtaining, Evaluating, and Communicating Information		

The DCI codes used refer to the grade level, the DCI heading as listed in the NGSS, and then a final number to indicate the bulleted idea or "element" from the tables in NGSS Appendix E. For example, **K-PS3.B.1**

What is in each lesson?

The following files are found in each lesson's Google folder:

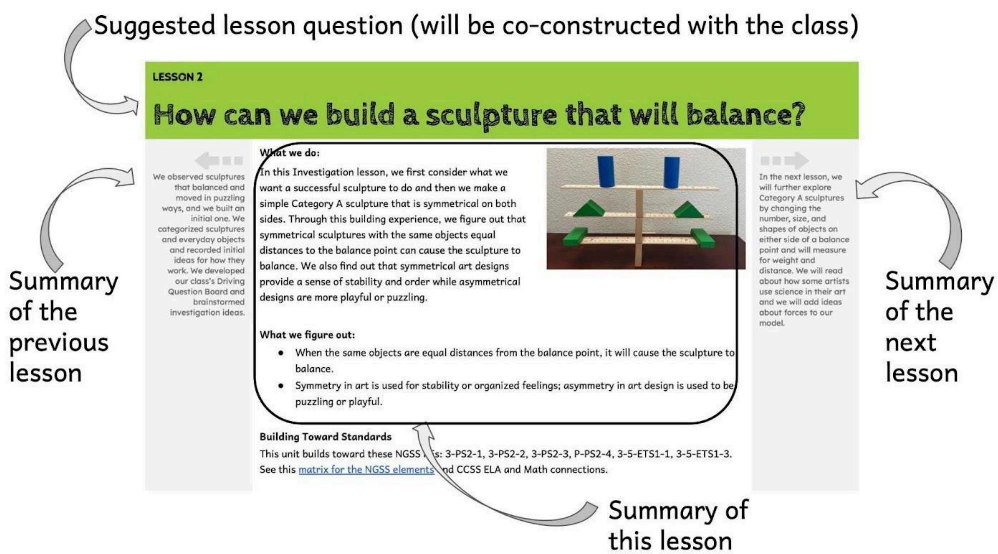
- Teacher guide (instructions for teaching the lesson, including materials needed, timing, etc.)
- Slide deck
- Applicable digital book or other text, such as an infographic, article, or card sort
  - If you purchase a kit, print copies of the books and card sorts are included.
  - Note that if all students will read a copy of an article, it will be a handout in the "student materials".
- Applicable teacher reference materials, such as activity setup details, assessment tools, etc.
- Student materials (in their own folder), such as handouts and assessments

Remember that, after saving your own local copy, you are able to make changes and adjustments to these materials to make them work best in your context (e.g., translate books into different languages, add images of your own classroom or community to the slide decks, modify student handouts as needed).

How are teacher guides organized?

Opening Page

Provides an overview of where this lesson is in the storyline of the unit--how this work ties in with making progress on students' questions



Learning Plan Snapshot

At-a-glance overview of the components, timing, and materials needed

Learning Plan Snapshot

	duration	slides	materials
NAVIGATE			
1. **Recall where we left off.** As a class, revisit ideas for how we might build sculptures that balance and then focus on Category A sculptures.	5 minutes	A	3.1 Lesson 2 Slides, Our Initial Ideas: How They Work chart, Ideas for Investigation chart
EXPLORE			
2. **Define a purpose.** As a class, define the problem and list what a successful sculpture will do if it works as intended.	15 minutes	B	“A Successful Sculpture Will…” chart, marker
3. **Plan and build a design.** Use our ideas about a successful design to build a symmetrical sculpture that balances.	25 minutes	C	Initial Category A Sculpture, Initial Sculpture Design: Category A
CONNECT			
4. **Read a book.** As a class, read aloud the book, *Symmetry*, and discuss ideas about how symmetry and asymmetry are used in artistic designs.	15 minutes	D	Symmetry
SYNTHESIZE			
5. **Develop our model.** We work together to develop our class model to represent what we figured out during our building process.	15 minutes	E	Initial Sculpture Design: Category A, Our Growing Ideas chart, marker

Materials Preparation and Checklist

Indicates (and links to) the materials needed for the lesson, and gives basic setup instructions (More involved activities will include a specific teacher reference with more details.)

Lesson Materials and Preparation

Per student:	Per small group:	Per class:

• Initial Sculpture Design: Category A	• **Initial Category A Sculpture**
	  • 3 rectangular blocks
	  • 3 wood rulers
	  • 3 pairs of identical objects
		• 3.1 Lesson 2 Slides
		• Our Initial Ideas: How They Work chart
		• Ideas for Investigation chart
		• “A Successful Sculpture Will…” chart
		• marker
		• Symmetry
		• Our Growing Ideas chart

Preparation Checklist • Estimated time: 20 minutes

- ☐ Be ready to use 3.1 Lesson 2 Slides.
- ☐ Have ready a print copy of Symmetry or plan to project the slide deck to read this text aloud in the Connect. If you have time or examples, consider replacing some of the photos with local examples of symmetry or asymmetry that students might have experiences with or would make the book more relevant to them. These could include culturally-relevant artwork or art from local artists, museums, or other community-based groups. If you are using a printed version of the book, consider adding slides to supplement the book with more local images.
- ☐ Print the handout, *Initial Sculpture Design: Category A* for each student. This lesson also includes an optional handout, Sculpture Planning Scaffold, to provide additional support for any students who may want or need more time to plan their sculptures prior to building them.
- ☐ In 3rd grade OpenSciEd, the units include a class-level Our Growing Ideas chart similar to the units in K-2. However, if your students are ready to begin tracking their ideas individually or in combination with a class-level chart, print My Growing Ideas for each student. Use this handout periodically throughout the unit to track the progress of student ideas over time. Consider adding the lesson question to the handout before making copies to reduce the writing burden for students.
- ☐ Create bags or bins for the small group sculpture building. Each bin should include:
  - ☐ 3 rectangular blocks (to be used as the support blocks as the base and between tiers)
  - ☐ 3 wood rulers (to be used as the support bars of the sculpture; students can build up to 3 tiers)
  - ☐ 3 sets of identical objects. There can be different shapes of wood blocks, but each group needs pairs of identical blocks. If possible, for this building activity, make sure the objects are also identical in color so that the sculptures they build are visually symmetrical.
- ☐ To clean up materials from the materials after the sculpture building, have students place the items back into the bins. All the items will be used again throughout lessons 3-8.

Lesson Vocabulary

Lists the words introduced in the lesson and shows the component where they will be explicitly discussed

Lesson 2 Vocabulary	NAVIGATE	EXPLORE	CONNECT	SYNTHESIZE	NAVIGATE
Unit-Specific Science Ideas These are words that students will use for sensemaking in this unit. We will continue using them throughout the unit, so post them on the Word Wall.				balance point	
Science Practices and Concepts That Build over Time These are words best learned as students engage with them over time. We will revisit them across units and grade levels.		investigation procedures			

Lesson Learning Goal(s)

Outlines the main CCC, SEP, and DCI students use in the lesson; aligns with the lesson's assessment opportunity

Three-dimensional Learning Goal(s)

Using the lens of:	Students will:	To make sense of:	Lesson learning goal:
Cause and Effect	Ask questions and define problems	How to begin thinking about criteria for success and what designs might be limited by.	**2.A** Identify criteria for success and constraints and routinely test what works and doesn't work (cause-and-effect) for a sculpture design to stay balanced and not fall over.

Lesson Assessment Guidance

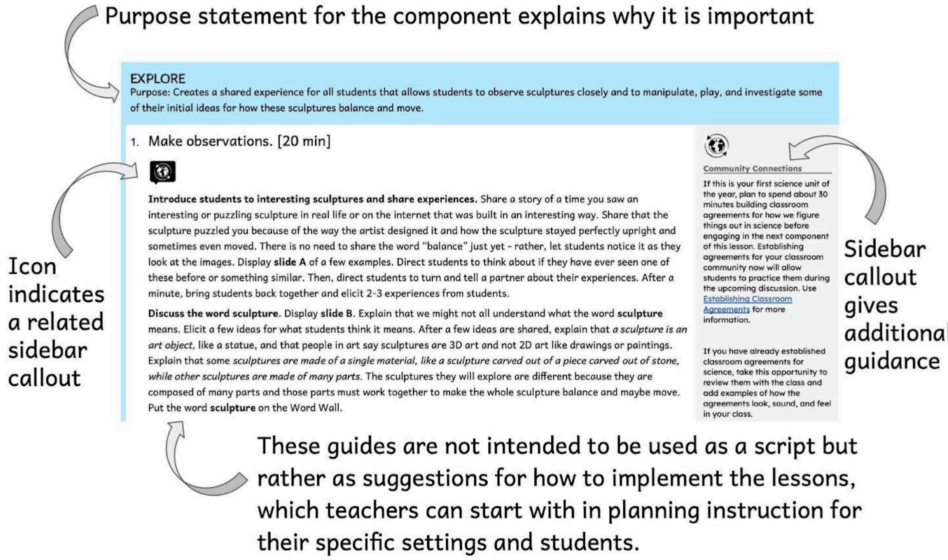
Outlines what student ideas to look and listen for, where in the lesson to look/listen for them, and what to do with that assessment information

Lesson Assessment Guidance

What will students do?	Where can I check for understanding?	How can I use this assessment information?
2.A Identify criteria for success and constraints and routinely test what works and doesn't work (cause-and-effect) for a sculpture design to stay balanced and not fall over.	**Assessment type:** Pre-assessment **Where to check for understanding:** During an initial brainstorm of ideas for the "A Successful Sculpture Will" chart, and then when the chart is revisited after building the sculptures. **What to look and listen for:** Ideas that the sculpture needs to (criteria) stay balanced, upright, and not fall over; ideas about what they did during the investigation to cause the sculpture to balance (e.g., set objects down at the same time, make sure they were equal distance). Students may also express, through words and gestures, ideas about how their sculptures are limited by the materials (constraints) – a block, ruler, and identical objects.	Use this assessment opportunity as a pre-assessment of students' initial ideas regarding what a successful sculpture needs to do (criteria), what their designs are limited by (constraints), and how they can test what works and doesn't work. It does not need to be graded since it is their first time considering criteria and constraints. These explicit terms will be introduced later in the unit. For now, use this moment to gauge students' initial conceptual understanding of these ideas and encourage students to begin thinking about how tracking their design needs and limitations will help them make sure they are building a successful sculpture because it can help us stay focused. Students will continue to expand on these ideas across the next several lessons.

Within Each Component

The text of the teacher guide is not intended to be used as a script. Rather, the suggestions given are starting points for teachers to plan instruction for their specific settings and students.



Prompt-Response Tables

Some tables include only two columns.; The prompts are suggested, and the student ideas to look and listen for are not intended to be exhaustive--rather, they are examples of what students might share.

The third column (when present) offers talk moves to help the teacher facilitate student-to-student discussion.

Prompts to use	Ideas to look and listen for	Possible follow-up responses
What causes the sculpture to stay balanced or fall over?	*Using flat things.* *Going slowly and putting objects on at the same time.* *Putting bigger things on the bottom and smaller ones on top (or vice versa).* *A bump from someone or a shaky table may cause the sculpture to fall over.* *The weight of objects is important.*	What do you mean by the words "balance" or "stable"? Why does ___ cause it to balance? (e.g., being flat, equal weight, etc.) Did we see examples of ____ being used? (e.g., non-flat objects) Why did doing ____ cause it to fall over? Could something else be causing it to balance or fall over? Who agrees with that idea? Who has a different idea? I see you doing ___ with your hands. Can you say more about what you mean?

What are Our (or My) Growing Ideas charts?

How do grades K-3 classes record and reflect on their progress toward answering their questions?

In grades K-3, the class uses a collective Our Growing Ideas chart to synthesize ideas at the end of most lessons and to support navigation and coherence across lessons. The teacher facilitates co-construction of a row in the chart per lesson using student ideas, artifacts, drawings, and images. Sample charts are provided in the materials, but teachers use the students' own language, ideas, images, artifacts, and examples, including having students participate in recording those ideas on the chart.

If your school uses KLEWS charts, you can shift the Our Growing Ideas chart to a KLEWS chart. Information in "What did we figure out?" would go in the "L," and the "How did we figure it out?" would go in the "E."

In grade 3 units, teachers have the option of using individual My Growing Ideas charts when students are ready, to support the transition to the format students will use in grades 4 and 5.

How do grades 4 and 5 students record and reflect on their progress toward answering their questions?

In grades 4 and 5, students use individual My Growing Ideas charts, which provide a personal space for students to process what they are making sense of and see how their ideas are growing and changing over time. Students can look back through their My Growing Ideas charts to reflect on what they have figured out in the unit, such as to support summative assessment opportunities.

My Growing Ideas charts are provided as handouts in lessons where designers felt they would be most useful, and/or teachers can support students in creating a simple T-chart in their notebooks to record the same ideas. Teachers can choose to use My Growing Ideas charts more or less often depending on the needs of their classroom.

Since these charts provide personal thinking space, they are not intended to be scored or graded. However, teachers may choose to circulate in the classroom while students write and draw, and/or ask students to leave their notebooks open afterward to check in with their ideas and truly inform instruction for next time.

This routine of individual students' documenting their ideas as they grow and change continues with Progress Trackers in OpenSciEd Middle School and OpenSciEd High School.

Building an Equitable Classroom Community for Science

Our Equity Design Stance

The OpenSciEd Elementary program aims to create equitable science instruction for all students, centering students' resources, interests, and identities in the classroom community's sensemaking work. Specifically, our materials are grounded in an equity design stance that supports and intentionally makes space for all students to be(come) expert learners of themselves and engage in sensemaking in ways that are authentic to them, including ways that are often unnoticed or are devalued in school spaces.

In particular, there are five principles that guide our equity design stance. Though described separately, it is important to note that these principles are not mutually exclusive and often intersect in critical ways. The following table describes the five principles that guide our equity design stance (left column) and includes some examples of how they manifest in OpenSciEd Elementary materials (right column).

OpenSciEd Elementary Equity Design Principles	
Principle 1 - Engage and value students' diverse identities, cultures, experiences, and communities.	• A Welcome Letter is in Lesson 1 of every unit. • Students are encouraged to consider related phenomena. • Lessons include frequent integration of community connections, often in the Connect component. • Texts are intentionally designed (images, words, content) to center different students' identities, backgrounds, and experiences so they have opportunities to see themselves and their communities.
Principle 2 - Center students' language resources and practices.	• Handouts provide space for students to capture their ideas and noticings across modalities (e.g., writing and drawing). • Teacher guides include prompt-response boxes that support teachers in noticing not just *what* ideas and questions students share, but also *how* they might be expressed (i.e., Look and listen for...). • Assessment documentation tools, such as the Following Student Sensemaking tool, support teachers in noticing the vast ways students might express their current and evolving understandings of the focal phenomena.

OpenSciEd Elementary Equity Design Principles	
Principle 3 - Dismantle barriers to participation.	• OpenSciEd units are designed based on Universal Design for Learning (UDL) guidelines to provide equitable and accessible learning for all students. • Teacher guides include callouts titled "Broadening Access" that provide guidance around how to ensure all students have meaningful access to, and engagement with, the learning experience.
Principle 4 - Build and sustain inclusive, collaborative norms and routines.	• Classroom Agreement lessons support teachers and students in collaboratively developing, revisiting, refining, and expanding upon their own agreements for how they aspire to equitably learn and be together in science. • Teacher guides include callouts titled "Community Connections" that provide guidance around how and why to encourage students to check in on their classroom's agreements.
Principle 5 - Use science to figure out and better understand meaningful phenomena, and to solve meaningful problems.	• OpenSciEd Elementary unit writers used surveys--that are age appropriate and elicit student ideas across modalities--to gauge student interest around possible unit anchors and related phenomena. • Many units include opportunities for students to engage in engineering design challenges that are meaningful and/or local to students. • Units often include opportunities for students to apply what they have learned to their local context.

What are Classroom Agreements in OpenSciEd Elementary?

OpenSciEd Elementary materials center students collectively *figuring out* (instead of *learning about*; Schwarz et al., 2017) science ideas through various types of sensemaking activities, such as investigations, interacting with different types of texts (e.g., books, videos, podcasts), discussions across participation structures (e.g., pairs, small groups, whole class), and developing and revising explanations and models for natural phenomena. Meaningfully engaging in this type of rich sensemaking work requires a classroom culture where all students feel like they belong and where it is safe to participate (often in new ways), share their ideas, disagree, productively struggle together, and grapple with uncertainty (Carlone & Smithenry, 2014; Manz & Suárez, 2018).

To create such a classroom culture, it is important that all students' varied and intersecting backgrounds, experiences, and ways of knowing, being, and doing are welcomed, noticed, and leveraged to help develop and push the classroom community's learning forward (Bang et al., 2017). This is particularly important for students who have been historically excluded or underserved in science classrooms, such as students with disabilities, multilingual students, and students from nondominant[1] racial and ethnic groups (Lee et al., 2014). The development and ongoing refinement and use of classroom agreements that explicitly focus on the class's "daily practices, the accessibility of those practices for all learners, and the implicit meanings of what counts as 'being scientific' prompted by those practices" (Carlone & Smithenry, 2014, p. 71), can help foster a more equitable classroom culture that supports all students' science learning and science identity development.

The Classroom Agreements Lesson Set

What is it, and what is its purpose?

The OpenSciEd Elementary K-5 Curriculum includes a Classroom Agreements Lesson Set (made up of four mini-lessons) aimed at helping a teacher and the students establish, revisit, and refine *Classroom Agreements for Learning and Being Together in Science*. Classroom Agreements Lesson 1 is meant to take place early in the school year, ideally during the beginning of the first OpenSciEd Elementary unit. Classroom Agreements Lessons 2-4 can be incorporated at different time points according to classroom needs, opportunities, and/or when new types of learning activities are introduced (e.g., the first time students critique their peers' models, after a Building Understandings Discussion). Classroom Agreements Lessons 2-4 are unpacked further in the subsection "When and how should you revisit the Classroom Agreements?".

There is an opportunity for students and their teacher to develop classroom agreements in the first lesson of each OpenSciEd Elementary unit. After engaging with the unit's anchoring phenomenon, the teacher guide encourages teachers to carry out Classroom Agreements Lesson 1 (if they have not had a chance to do so already in the school year). This mini-lesson helps the teacher facilitate a class activity around "What counts as science?" and the ways that scientists work together. The goal is for students to develop wide-ranging views around the ways science is done and by whom and for what purposes, and for these ideas to then inform how students want to collectively do and learn science as a class.

Classroom Agreements Lesson 1 begins with students making and discussing observations about images that capture science being done in many different ways and by many different types of people across a variety of spaces. For example, one of the images includes a group of children making observations and collecting data outside by a shoreline, another shows a teacher and students engaging with a science text in their classroom, while another captures an astronaut in an international space shuttle. The intention of these images is to show that there is no one way to do science, that anybody can do science, that science is done in many different contexts, that people use different tools to engage in science, and that people communicate science ideas through various forms and by drawing upon many different resources. It is critical that all students see themselves, in some capacity, in these images. As such, if there are additional examples of "What counts as science?" that are particular to your local

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[1] The term *dominant* does not refer to numerical majority but instead highlights institutionalized prestige (i.e., whose ways of knowing, doing, and being are traditionally encouraged, noticed, and praised in schooling spaces) (Gutiérrez & Rogoff, 2003).

context (e.g., individuals tending to a neighborhood community garden, folks picking debris from a nearby river, a family science night that your school holds) and/or to your student population, we highly encourage you to incorporate those into the slides to support and enhance this discussion.

Students' observations of these images then lead to a conversation around the agreements that students want to make with themselves and with each other for learning and doing science in their classroom community. Given that OpenSciEd is rooted in a commitment to equitable science instruction for all students (see the OpenSciEd Elementary Design Specifications on this web page for details), our materials recommend the following four starting agreements:

1. *We can do science in many different ways.*
2. *We share ideas even when we are not sure.*
3. *We look, listen, and respond to each other's ideas.*
4. *We let our ideas change and grow.*

When gathering student ideas around what each agreement might look and sound like, we recommend encouraging students to express their ideas in different ways, and for teachers to document these ideas in ways that reflect *what* students shared and *how* (e.g., drawings, descriptors or images of gestures, example student work, pictures from class, written text). Furthermore, the recorded ideas should represent consensus among the entire classroom community. To help reach, and check for, this consensus, we suggest that teachers provide students plenty of time for discussion across participation structures, including individually, in pairs and/or small groups, and as a whole class. Furthermore, to help make classroom participation more equitable, we recommend the use of different strategies to ensure all students agree with the recorded ideas and the ways these ideas are being recorded. For instance, your class might use certain body gestures like head nods, thumbs up, or the "I agree" hand sign.

Additionally, for each agreement, it is important that students discuss how they might feel about the proposed agreement. For instance, the second agreement (*We share ideas even when we are not sure*) might make some students feel relieved because it opens up the space for any and all ideas to be shared, without the pressure of having to know the "right answer." However, the same agreement might make other students feel nervous because that practice is not one commonly welcomed, or praised, in school spaces (Carlone & Smithenry, 2014). It is important to acknowledge and validate all feelings that students share, and to jointly develop a plan for how to help each other out when more challenging or upsetting feelings emerge. For example, students might have a "feelings buddy" they check in with, or a particular gesture that they convey to the teacher if they want or need space and time to process their emotions. If challenging or upsetting emotions come up for students, it might help them to hear appreciation from their teacher and peers for trying out something new. In such instances, some students might also find it helpful to talk about how each agreement relates to the ways scientists work together (i.e., connecting back to the purpose of these agreements).

Ultimately, what is most important is that the agreements reflect the classroom community members' ideas and promises to one another, so if and when needed, teachers should modify agreements until this is the case. Returning to the previous example, students might want to modify the second agreement to: *We share ideas even when we are* *not sure, and it is OK to ask for more time to do so*. The additional note about asking for more time might be helpful to a variety of students for a variety of reasons (e.g., for students who might need more time to process ideas they are making sense of).

There is also extra space for students to develop additional agreements that they feel are important and not fully captured by the other agreements. For instance, on the following page, one of the example Classroom Agreement handouts includes a note from a student to "*Have fun!*". (See examples at the end of this section.) Students may or may not come up with these additional agreements during Classroom Agreements Lesson 1. Instead, new ideas might emerge as students continue to engage with OpenSciEd Elementary science units. When such ideas come up, we encourage the class to take the opportunity to revisit, add to, and amend the Classroom Agreements chart.

When and how should you revisit the Classroom Agreements?

A classroom culture that supports equitable science learning for all students takes time and work to establish and to maintain (Carlone & Smithenry, 2014). For that reason, it is necessary that students think of the classroom agreements as dynamic and ever-evolving, and that they revisit and engage with them often. Suggested moments to revisit the classroom agreements are embedded throughout OpenSciEd Elementary units. For example, before students partake in a new type of activity, like creating a Driving Question Board, our materials suggest that teachers revisit with students the agreements they made. Spending time revisiting classroom agreements can help students try out new things. Doing so can also help students understand how these new activities are important for doing science and figuring out natural phenomena. This is especially important because many of the sensemaking activities that students engage in during OpenSciEd Elementary units might be very different from how students are accustomed to interacting with their classmates in school. Teachers might also find that moments emerge during instruction that naturally segue toward the class revisiting and, if needed, amending students' previously developed agreements. As students develop familiarity and a sense of ownership with the equitable classroom culture that has been fostered over the school year, it is likely that they too begin to ask for the class to revisit the classroom agreements. We encourage teachers to take the time to do so when such moments arise.

While Classroom Agreements Lesson 1 is focused on establishing a class's initial agreements, Lessons 2-4 are focused on revising and expanding these agreements. Specifically, Classroom Agreements Lesson 2 is centered on helping the students and teacher collaboratively establish an understanding around expansive ways for engaging in science and engineering practices. Lesson 2 begins with a class conversation about the *Classroom Agreements for Learning and Being Together in Science* and why it is important to revisit and expand upon them. The teacher then informs students that they will focus on the first classroom agreement, "We can do science in many different ways." Students are then prompted to individually reflect on a specific learning experience and all of the different ways that they engaged in it. Each unit will provide specific suggestions about which learning experience to focus on. In common, however, is that these experiences include rich opportunities for students to engage in one or more science and engineering practices to grapple with and/or figure out part of the focal anchoring phenomena. After individually reflecting, students share their ideas with a few peers. With the ideas just brainstormed and discussed in mind, students then create a representation of themselves that captures all the different ways that they did, and could have, figured out and communicated science ideas. If needed or desired, teachers can provide students with a template in which to create their representations. Students then engage in a gallery tour of the class's representations—we encourage the teacher to create one too!—with the goal of noticing all the different ways that members of their classroom community do and communicate science via science and engineering practices. Afterward, the teacher facilitates a whole class discussion where students share key ideas from the gallery tour. These ideas are then added to the Classroom Agreements chart. We suggest that these ideas be added in many different forms (e.g., drawings, photographs of students engaging in investigations) so as to mirror the main takeaway from Lesson 2. Going forward in the unit, students are encouraged to recognize the various ways that their peers communicate ideas and to continue adding examples to the Classroom Agreements chart.

See the following example as a reference for how the chart might look later in the school year, after the class has had many opportunities to engage with and add more ideas around how these agreements play out in their particular classroom. Your classroom's agreements will look different because you are using your students' ideas, words, and drawings. Your agreements might include references to other expectations/norms/rules that you already have in your classroom or school.

Sample chart coming soon!

Frequently-Asked Questions about OpenSciEd Elementary Classroom Agreements

When should I draft initial classroom agreements with my students? Unit authors recommend pausing at a strategic moment during Lesson 1 (such as before the Synthesize), so that you can refer to the work students did as scientists as they initially engaged with the unit's anchoring phenomenon when motivating why and how agreements can help the class figure things out in science. Because OpenSciEd Elementary units were developed to be modular (in other words, teachers might teach the units for a given grade in different orders), there is suggested navigation offered in the Lesson 1 teacher guides of every unit.

Alternatively, teachers may choose to draft agreements entirely before beginning this unit, as a way to position students as scientists before beginning any science work. If you choose this option, be sure to pause occasionally throughout the first lesson(s) to add, revise, and/or expand upon ideas about what the agreements look and sound like in your classroom as students do sensemaking work. Doing so will help students understand the purpose behind developing classroom agreements for learning and doing science together.

How were the four starter agreements decided upon? The OpenSciEd Elementary Developers Consortium worked alongside K-5 field test teachers and co-design teachers to determine the four starter agreements that are described in Classroom Agreements Lesson 1 and revisited and expanded upon in the other Classroom Agreements lessons. Furthermore, we consulted research literature that has examined factors that positively impact students' experiences learning and doing science, including research focused on developing students' science identities. The four starter agreements represent this collective and intentional effort.

Can we modify the classroom agreements? The classroom agreements that you collaboratively develop with your class should ultimately represent the ideas shared by the students. As such, if your class chooses to word or describe an idea differently than what is provided in Lesson 1, follow the students' lead! This is also where space for the potential fifth classroom agreement comes in handy so that students are really taking ownership over how they want to engage in sensemaking work within their science class.

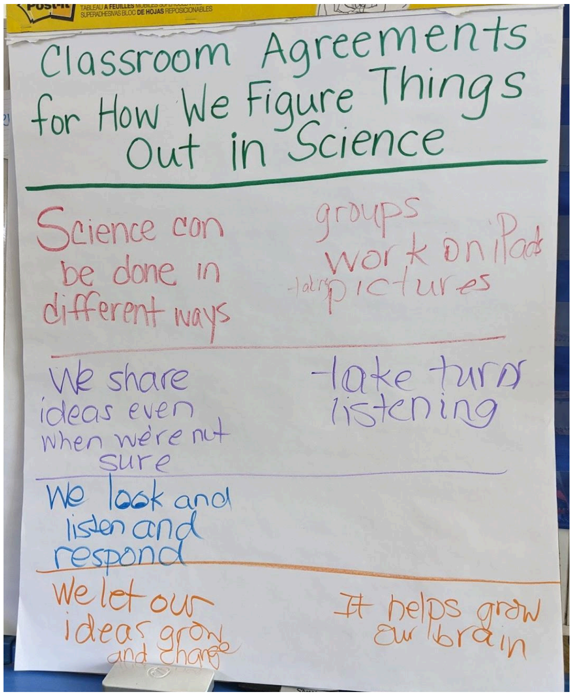
Why do we need separate classroom agreements for learning science? Elementary school teachers tend to create and/or use classroom agreements (frequently referred to as rules or norms) with students. Often, these agreements are common across an entire school and tend to focus on students being respectful, safe, and trying their best. Those are important promises for students to make to themselves and their classmates. As such, it is not surprising for a teacher to wonder whether we need separate classroom agreements for learning science. Though we understand this question, we highly encourage teachers to develop separate classroom agreements for science. OpenSciEd Elementary units engage students in doing and figuring out science in new and exciting ways that might not align with how students (and even teachers) are used to learning science. Many of the agreements that our materials suggest encourage and support classroom members with being open to this instructional approach. Moreover, historically, science has not been taught in equitable ways. Certain ways of doing and communicating science have been welcomed and privileged in school spaces (i.e., those of white, Western, English-speaking, upper-middle-class individuals; González-Howard et al., 2023; Bang et al., 2017). OpenSciEd Elementary materials promote an expansive view and approach to science instruction and the classroom agreements also reflect key ideas needed for fostering more equitable science classroom communities (Carlone & Smithenry, 2014).

Are there major differences between the K-2 and 3-5 versions? There are two versions of Classroom Agreements Lesson 1, one for grades K-2 (lower elementary) and another for grades 3-5 (upper elementary). Overall, there are no major differences between these two versions, as all students must receive the same equity-driven message that science can be done in many different ways, by all kinds of people, and for a variety of purposes. The slight differences that do exist between the two versions are in the number of images students consider for what counts as science, and the suggestions around how students might record their ideas throughout the lesson. (The 3-5 version suggests providing students with a handout of the Classroom Agreements chart along with a whole-class version for ease of recording everyone's ideas.) These differences are mainly to make the materials more age appropriate. For instance, upper elementary students have developed writing skills and tend to do more independent work.

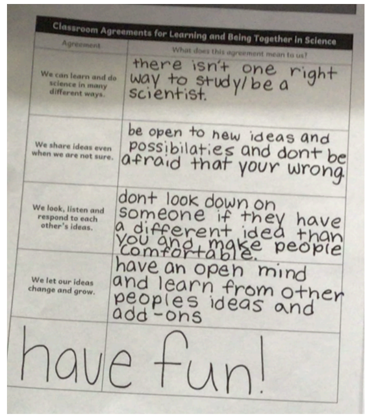
Can the Classroom Agreement Lessons be modified? We encourage teachers to use their professional discretion, available resources (e.g., technological tools, such as smart boards or Google Classroom), and knowledge of the particular students in their classroom to modify these lessons, if and how needed, to best support students. For Classroom Agreements Lesson 1 in particular, we suggest that, if possible, teachers tailor and localize the examples of "What counts as science?" that students observe and discuss.

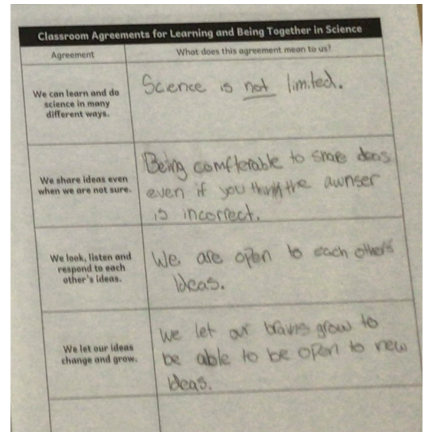
What might example artifacts from Classroom Agreements Lesson 1 look like? Following are example Classroom Agreements charts and handouts developed by students who engaged in OpenSciEd Elementary units. When considering the 5th-grade examples, it is important to note that the 3-5 version of Lesson 1 has students make sense of the agreements independently before sharing their ideas with the class.

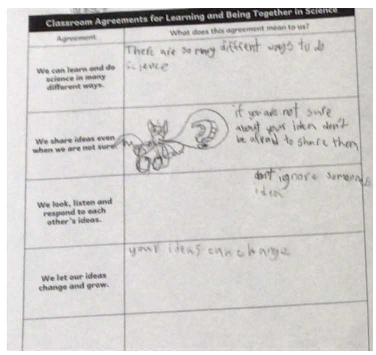
Example chart from a kindergarten class:



Example handouts from a 5th-grade class:







What are "Community Connections"?

Community Connections are handouts intended to go home with students rather than be added to science notebooks (at least not right away). Each unit's first lesson includes a Welcome Letter (which is one type of Community Connection handout) to introduce caregivers to the phenomenon students will be exploring, along with questions that caregivers can ask to start and support ongoing discussions about the science work students are doing in their classrooms. Other Community Connection handouts invite students to work with trusted adults to engage in science activities outside of school, such as finding examples of phenomena that are related to the unit phenomenon, sharing and discussing a model they created, or bringing in ideas from their family or community to support work they will do in the classroom.

It is important to note that sending Community Connection handouts home with students is not considered optional--we want students and their caregivers to see how their lives and experiences are valuable to the science work happening at school. However, whether students complete Community Connection handouts is optional. These tasks should not be considered "homework" and students should not be penalized for leaving them undone. Guidance is provided in the teacher guides for supporting students who do not complete a Community Connection activity so that all students (regardless of the extent to which they engaged with or completed the Community Connection handout) can still fully participate in the work of that lesson.

Supporting Discussion

Providing intentional opportunities for students to discuss their ideas with the whole class is critical in supporting their science sensemaking. During these discussions students' thinking becomes public to the rest of the classroom community. This visibility of ideas is critical so that the class can hear new ideas and engage with them in order to move forward students' understandings of the focal phenomena. That said, the rich anchoring phenomena that students engage with across OpenSciEd Elementary units will provide students with a LOT to talk about. As such, whenever there are key opportunities for students to share their initial and evolving ideas and connections they are making between various sources of evidence, the unit materials provide specific teacher and student prompts and ideas to look and listen for. These are intended to focus and support students' sensemaking work.

Discussion Types

OpenSciEd Elementary (like OpenSciEd Middle School and High School) names three specific discussion types:

- Initial Ideas Discussions
- Building Understandings Discussions
- Consensus Discussions

We specifically name these discussions

- when the whole class is participating in a discussion that is orchestrated by the teacher, and
- to facilitate all students' engagement in and work toward collective sensemaking.

These named discussion types mark key moments in the storyline where the class is working to move forward in their figuring out. Each type of discussion serves a different purpose, is useful in specific components of a lesson or unit, and has different characteristics depending on its purpose.

The chart on the following page summarizes the purpose of each of the three discussion types as well as the teacher and student roles in each of them. Specific prompts to support these discussions are provided in the teacher guides, but general prompts for teachers and students are available in Appendix B of this Handbook.

Initial Ideas Discussion

Purpose/Goals in the Storyline

- Elicit initial ideas and relevant prior experiences, usually about the anchoring phenomenon/problem.
- Share/make sense of tentative ideas.
- Figure out the gaps in our understanding, promote curiosity, and identify the important questions we need to investigate.
- Elevate and honor the experiences and resources of all students.

Teacher Role

- Focus the class on sharing lots of ideas, raising questions, clarifying, or adding on to what someone has said rather than on debating or arguing.
- Ask students how they might test or explore their ideas.
- Ask for or provide a synthesis of ideas from the discussion.

Student Role

- Share ideas and experiences.
- Clarify one's own thinking.
- Ask each other questions.
- Consider how others' ideas contribute to developing shared understanding.

Building Understandings Discussion (Idea)

Purpose/Goals in the Storyline

- Share, connect, critique, and build on others' findings, claims, evidence, and explanations from an investigation.
- Arrive at tentative conclusions: We have a new piece of evidence... what does that mean for us?
- Use as an opportunity for teachers to formatively assess lesson-level collective sensemaking (though not all students may agree, and our model or explanation is not yet complete).

Teacher Role

- Set and maintain focus around the specific lesson question.
- Invite students to share claims, explanations, and solutions with a focus on elaboration of evidence and reasoning.
- Encourage alternative explanations using evidence.
- Help the group come to tentative conclusions and next steps to investigate the anchoring phenomenon.

Student Role

- Attempt to explain a lesson-level question.
- Use data from lesson investigations as evidence to support claims or partial explanations.
- Compare, contrast, and ask questions about each other's claims, evidence, and explanations.

Consensus Discussion (Idea + Idea + Idea)

Purpose/Goals in the Storyline

- Work toward a more complete, collective explanation or model.
- Use evidence from prior investigations to make progress on the phenomenon.
- Capture where we still disagree and need more evidence.
- Celebrate what we figured out about our anchoring phenomenon.

Teacher Role

- Help take stock of and publicly revise earlier ideas.
- Encourage discussion where we need to clarify our ideas.
- Press toward a common explanation or model.
- Establish next questions/next steps for investigations.

Student Role

- Agree on what we know.
- Agree on what we don't know and what we need to move forward.
- Agree and disagree about our ideas.
- Challenge and defend our ideas.

What is a Scientists Circle? Why do we use them?

- Your class may already sit in a circle in other parts of the day, and it is important to sit in a circle for many science discussions, as well. When students sit in a circle with the teacher among them rather than in front of them, they can see and speak directly to each other, which supports students' engagement and builds a sense of shared mission. This arrangement also supports a classroom culture that positions students as "knowers" and "thinkers" who each have something important to share with peers and are capable of engaging in the work of figuring things out.
  - If the class is arranged with all the desks facing forward, then the emphasis is more likely to be on the teacher as the sole source of knowledge. This structure can discourage students from interacting with one another. This type of discussion presents a narrow view of what it means to do science. Changing the physical arrangement of the classroom (with students seated facing one another in a circle), coupled with utilizing moves that shift the authority of the classroom (e.g., facilitating student-to-student talk, asking students to publicly record the ideas the class is agreeing on), can lead to more opportunities for students to make meaning collaboratively, through talk.
- Scientists Circles can be convened at any time, but they are most often used at moments in which the class needs to work toward consensus on ideas they have figured out. It is often important to have access to chart paper, a projected digital space, and/or whiteboards to capture ideas the class agrees on and ideas they still have questions about.
- Take time to plan and practice logistics for forming, equitably participating in, and exiting a Scientists Circle so students can quickly and smoothly move between this and other activity structures. Depending on the age/size of the students and the classroom configuration, some classes sit on a rug together, some move furniture to assemble a circle of chairs, and some stand around the perimeter of the room.

How can teachers facilitate more equitable discussions?

Think about the goal(s) of the discussion

Based on the discussion type and its purpose in the storyline, consider what will make the discussion most equitable and for whom.

- If the goal is hearing many different ideas (such as in an Initial Ideas Discussion), consider making sure that you invite and include the ideas of students who are less loud.
- If the goal is to unpack students' ideas (such as in a Building Understandings Discussion), consider offering a couple of students time to think deeply, and support them in figuring out how to express their ideas. The quick pace of many classroom discussions does not always promote best teaching practices for all of our students.

Offer think time before and/or during whole group discussion

Students often benefit from time to process, plan, and/or practice sharing their ideas. Before asking students to go public with their ideas, consider any of the following strategies.

- Turn and talk with a partner
- Prompting students for different means of expression (e.g., How could you use your body to show that? How could you draw that? How would you say that in another language?), paired with individual think time before sharing
- Small group meeting time before a whole class discussion

Keep track of which students are sharing

Keeping notes about who is sharing, what they share, and how they share can be a useful tool to help you support all students in sharing over the course of several discussions. Consider using the following strategies.

- Following Student Sensemaking tools available in many units, especially in grades K-3
- An informal "Ideas Catcher" document where you jot notes about who shared what ideas in what ways
- Discussion mapping

Support student-to-student talk

When co-constructing classroom agreements, include an agreement that encourages students to look, listen, and respond to each other's ideas. Help them do this by

- providing sentence starters and prompts that students can use to interact with each other's ideas (Examples are provided as handouts in every unit's first lesson, and many lesson slides for discussions include them.);
- establishing hand signals that students can use to nonverbally show agreement and/or wondering about what is being shared.

Plan ahead to use discussion time productively

Several key strategies can help teachers make discussions efficient, balancing between allowing the class to share a multiplicity of ideas and students' getting tired of sitting and trying to attend too long.

- Begin planning for a discussion well before it happens using The 5 Practices for Orchestrating Task-Based Discussions in Science (Cartier et al. 2013):
  - Anticipating: predicting how students are likely to respond to a task
  - Monitoring: taking purposeful note of what students are doing and saying as they are working on the task
  - Selecting: deciding what information and student ideas will be shared in the whole class conversation
  - Sequencing: deciding in what order the selected models or ideas should be discussed so students can make sense of the science ideas
  - Connecting: drawing student attention to the connections between the selected student information in a cohesive way that ultimately leads to a complex discussion that helps students further develop the construction of their ideas
- Recall that prompts provided in OpenSciEd teacher guides are suggestions and need not all be asked. Use the look- and listen-for guidance, and when the class has agreed on the key points, move on.

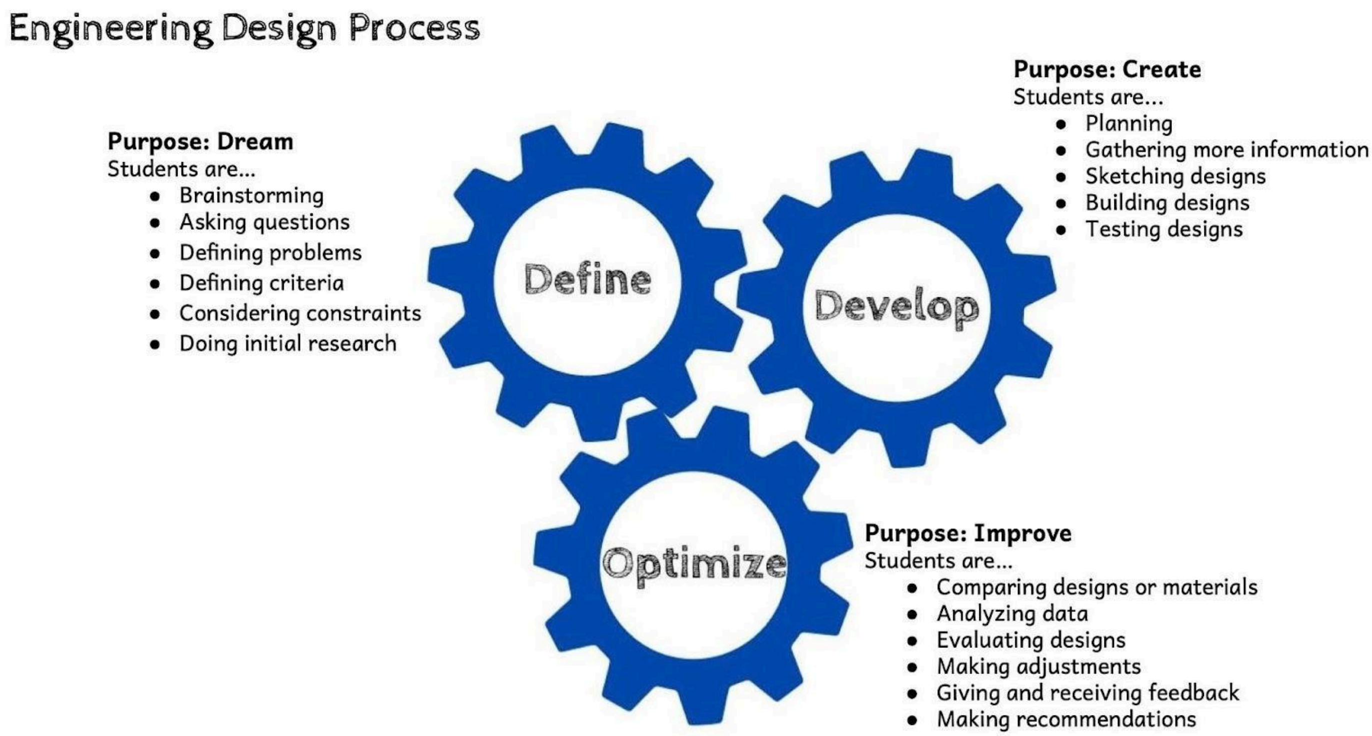
Incorporate movement

Increase student engagement by inviting students to contribute ideas with their bodies in addition to their voices.

- Make "turn and talk" into "stand and talk."
- Use inside-outside circles when it is helpful to have students share ideas with more than one partner in a row.
- For either-or questions, have students move to one side of the rug or room to represent which side they support.
- For questions with 3 or 4 possible responses, have students move to corners of the room representing different ideas.
- Ask, *How could you act that out?* or *Can you use your hands/body to show us what you mean?*

Engineering Design

At least two units per grade level provide opportunities for students to develop ideas and practices around engineering design. The following graphic illustrates how OpenSciEd Elementary developers have interpreted the engineering design process as outlined in the NGSS (see Appendix I), not as a linear sequence, but as a set of interworking phases. The details of this graphic are intended for developer and teacher use; only the gears are student-facing in grades 3-5.



The engineering design process looks and sounds different in each grade band. In grades K-2, students consider how problems to be solved through engineering design are different from problems in other contexts. K-2 students develop design solutions and compare them based on test results.

In grades 3-5, students build on the engineering design work they did in earlier grades and are more explicit about the aspects of the process. Grades 3-5 students define problems using criteria and constraints, conduct research to explore and/or develop multiple possible solutions, and use test data not only to evaluate design solutions but to improve on them.

Units that (Will) Include the Engineering Design Process

Unit	Overview of the engineering design process in this unit	Texts that support engineering design
K.1 Schoolyard Engineering	Students design, build, test, and share solutions for preventing the blacktop at school from getting too hot.	*Community Is Ready for a New Playground; Meet Lisa DeShano; Engineers Plan, Build, and Test Designs*
K.3 Mighty Movers	Students build and test a solution that uses pushes and/or pulls to change the speed or direction of an object.	*Engineering to Solve Problems*
1.2 Sound Signals	Students design, build, and test solutions for communicating signals across a distance using sound.	*Meet the Engineer: Matias Dermond*
1.4 TBD	Students design a solution using mimicry to solve a human problem.	TBD
2.1 Land on the Move	Students design, build, test, and compare solutions for preventing beach erosion.	*Engineers Test Solutions; Land Change Solutions Infographics; Solution Scientists*
2.2 Engineering Toys	Students interview kindergarten toy users, then design, build, and share their toy designs with kindergarteners.	*How Are Toys Engineered?; Engineers Make Arguments*
3.1 Balanced Art	Students consider why scientists carry out fair tests and conduct multiple trials, and how to record observations of their work.	*Scientists Use Procedures; Design Steps Infographic*
3.2 Fruit & Hazards	Students develop models for how windbreaks work to prevent damage to fruit trees, test those models, and then communicate with peers to compare what worked.	*Scientists & Engineers Make Arguments*
3.4 TBD	Students evaluate existing solutions about changes to ecosystems.	TBD
4.2 Electricity	Students design, build, test, and optimize a solar-powered device, then plan for how it could work in their community.	*Define, Develop, Optimize: Engineering Gaming Systems*
4.3 Islands	Students focus on optimizing a design to reduce the impacts of natural Earth processes on humans.	*Engineers Compare Solutions*
5.2 Water	Students design, build, test, and optimize water filters, and compare and evaluate their solutions. They then plan for how their solutions could be used in their community.	*Meet the Water Treatment Scientists & Engineers; Solving Water Problems; Optimizing Water Solutions*
5.3 Elwha River Dams	Students generate and compare possible solutions for protecting Earth's resources.	*Engineers Give Feedback*

Integrating Literacy

The goal of integrating literacy within OpenSciEd units is to offer opportunities for practicing reading, writing (including drawing/writing images, words, graphs, and diagrams), speaking, and listening to support engagement in science learning. When these components of literacy are aligned with science learning, students learn how to use oral (speaking, listening) and written (reading, writing) language to support their understanding of science and engineering practices. Students use reading, writing, speaking, and listening to communicate their science ideas while also supporting their ongoing science sensemaking. A focus on students' sensemaking allows for the integration of science and literacy practices because it involves using ideas, language, evidence, and experiences to find patterns and figure out how and why the world works. Integrating science and literacy practices is also valuable for student learning because it helps students engage in specialized reading, writing, speaking, and listening practices that mirror authentic practices used by scientists and engineers.

One of the ways that literacy practices are addressed in OpenSciEd units is through the English Language Arts Common Core State Standards. Opportunities for practice with these standards are outlined in lesson callouts and across each unit in the Common Core State Standards ELA connections matrix. Lessons are also designed to strengthen literacy practices by including activities that offer additional opportunities to read, write, and communicate science ideas in a lesson. For example, students use evidence from text or evidence from data they collect during explorations to support what they say in a classroom discussion or to support written explanations.

Emphasis on Communication

Active participation is a core emphasis of OpenSciEd units. OpenSciEd units address speaking, listening, and language development as students ask questions, share ideas, engage in discussions, and learn the language of science. Discussion, in particular, is used to support students so that they make connections between what they are learning and different components of a lesson, as well as other components and ideas presented across an entire unit. Communication is emphasized in these units because while children are learning to read and write on their own, they can simultaneously engage in science and literacy practices through oral language (e.g., oral explanations or argumentation) or through multimodal methods of communication (e.g., drawing models to show their ideas). To achieve this, students are frequently engaged in speaking, listening, and responding to others as part of their participation in science and engineering practices. The units provide guidance aligned to Common Core State Standards for speaking and listening, including standards for comprehension and collaboration, and presentation of knowledge and ideas. Also, lesson activities and texts are written to prompt and encourage students to participate in active discussion. Students regularly engage in peer-to-peer discussions to share, express, and refine their thinking based on new information. They also develop, present, and defend their ideas to one another. Students are encouraged to use all forms of communication in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details.

Reading Informational Text

The ability to read and comprehend science text is critical for engaging in science. In OpenSciEd units informational text is leveraged as a tool for students to gather more information, use new vocabulary, and engage in new ways of talking about their ideas. Using informational text to engage in science and engineering practices supports both science and literacy goals in elementary school. To further support these goals, informational texts are intentionally and purposely written by the OpenSciEd team to support students' sensemaking across each unit. These texts serve a variety of purposes across the lessons, including to

a. Support students in gathering information to answer a question, generating new questions, or better understanding a concept.
b. Expand students' understanding of a phenomenon to new contexts.
c. Provide new vocabulary, giving labels or names to things that students have already started to figure out.
d. Explain scientific practices with examples relevant to students' knowledge and experiences.
e. Introduce students to a broad range of people who engage in the work of science and engineering. Current and future texts will feature people of different ages, genders, cultures, abilities, and racial and ethnic groups engaged in the scientific enterprise, and include individuals with different perspectives who are working toward similar or different purposes, as part of different disciplines and communities (such as citizen scientists, families, or classmates).

Students engage in two types of informational text reading across the units:

a. Students in all grades participate in interactive read-aloud texts in which the teacher reads the text aloud to students and students engage in a text-based discussion. The read-aloud experience is "interactive" in the sense that students are asked questions and are encouraged to ask their own questions as they read. Prompts are provided for teachers to support interaction around the text. Students use information in the text, their prior knowledge, and class discussion to make sense of what is being read and to connect text-based ideas to their learning from explorations and other experiences across the unit. Interactive read-aloud texts are written to be approximately two levels above the students' current grade level. (For example, a 2nd grade teacher reads aloud 4th grade-level text.)
b. Beginning in 2nd grade, and more regularly in grades 3-5, students may engage with texts by reading text independently. Independent reading texts are written to be on grade level for students. (e.g., Students in 3rd grade read a 3rd grade-level text.) Some students may find independent reading challenging, and supports are provided in the teacher guide to scaffold these independent reading experiences. These scaffolds may include reading and discussing a text with a small group or reading with a partner. Teachers may also be encouraged to show, pronounce, and briefly explain the meaning of new or challenging words directly before students read a text containing these words. This will scaffold students' decoding and comprehension of the text. Before and after reading, the teacher guide provides supports for discussion of the text. Independent reading texts provide students the opportunity to practice reading science texts on their own in a scaffolded environment. Reading these texts helps students contribute to large group

discussions about the text itself and consider how information from texts can help them make sense of the phenomena they are studying.

The following table outlines the different types of texts and books used throughout the program.

Type of Text	Description	Purposes
Scientists/Engineers Make/Do Books	These books feature real scientists, engineers, and other individuals who are doing science in a variety of ways and for a variety of purposes.	➔ Explain how/why scientists/engineers engage in particular practices. ➔ Help students leverage the resources they have from their background and experiences and bring them into the science classroom. ➔ Students see how science and engineering practices are something that they can do in their daily lives. ➔ Students make sense of how scientists, engineers, or other people in STEM disciplines (e.g., doctors) analyze and interpret data and are able to compare how experts gather and interpret evidence related to the phenomenon. ➔ Students learn how phenomena can be studied beyond what can be directly explored in the classroom.
Meet the Expert Books	These books are biographies of real scientists, engineers, and other individuals who are doing or engaging with science in a variety of ways and for a variety of purposes.	➔ Share the ways that ideas from the unit are taken up by scientists, engineers, and others as part of their work. ➔ Encourage connections between students' experiences and scientists' expertise. ➔ Offer additional opportunities for exploration of a phenomenon beyond the scope of what students can directly explore in the classroom.

Type of Text	Description	Purposes
Information Books	These books provide additional information about topics that are important for student sensemaking; they can supply important vocabulary or terms related to the phenomena of study.	➔ Provide opportunities for students to obtain and evaluate information they need for sensemaking. ➔ Offer additional opportunities for exploration of a phenomenon beyond the scope of what students can directly explore in the classroom. ➔ Offer students the opportunity to connect their knowledge with vocabulary and use it in a meaningful context.
In Our Communities Books	These books feature fictional children (and their families, classes, peers, etc.) as they experience the same phenomena that OpenSciEd units are focused on.	➔ Students are able to connect and apply knowledge related to unit phenomena to explore how phenomena are similar or different across communities. ➔ Showcase the different ways that children and people in their community can be observing and/or doing science and engineering. ➔ Provide opportunities to represent the many roles, traits, and identities of children and their families. ➔ Students learn how phenomena can be studied beyond what can be directly explored in the classroom.
Websites	Original websites are developed to help students obtain additional information about topics that are important for student sensemaking.	➔ Provide opportunities for students to obtain and evaluate information they need for sensemaking. ➔ Offer additional opportunities for exploration of a phenomenon beyond the scope of what students can directly explore in the classroom. ➔ Students gain experience using technology to obtain and evaluate information.

Type of Text	Description	Purposes
Infographics	Infographics supply students with important information, images, graphs, and/or data that are important for student sensemaking.	➔ Provide opportunities for students to obtain and evaluate multiple types of information that they need for sensemaking. ➔ Offer students the opportunity to connect their knowledge with vocabulary and use it in a meaningful context.
Newspaper Articles	Newspaper articles elevate how different communities experience phenomena related to what students are making sense of; these articles reiterate the many ways that people engage in science work.	➔ Help students leverage the resources they have from their background and experiences and bring them into the science classroom. ➔ Students see how science and engineering practices are something that they can do in their daily lives.

Science Writing

OpenSciEd units are intentional about the purpose, placement, and variety of written work. Students engage in writing daily as they draw, write, and communicate their understanding of science ideas and practices through written text. Students' written work can provide a meaningful context for teachers to support sensemaking and prompt for evidence-based explanations. In OpenSciEd units, students have opportunities to write as part of engagement in science practices. This includes opportunities for students to individually draw and write as well as for shared writing opportunities (i.e., the teacher models science writing or scribes student's ideas). Students are encouraged to use many methods of writing to communicate their science ideas. For instance, they engage in drawing, creating models, writing informational texts, and collaboratively writing texts with their peers. Individual and shared drawing and writing are included in the lessons to underscore how different types of written language support science and engineering practices.

The aim of integrating written work in OpenSciEd units is to give students opportunities to practice communicating their science ideas. In service of this aim, written work included in the lessons does not focus on accurate forms in writing (such as perfect grammar or spelling). Written work integrates standards for writing from the Common Core State Standards.

Students in all grades will also participate in at least one shared research project. At least one unit in each grade will include a research project related to the phenomenon that they are studying. Students' research will be scaffolded according to the child's grade level and in accordance with the Common Core State Standards.

How do science notebooks support science writing?

Developing a science notebook can create a sense of ownership from students for their intellectual work in the classroom. It can also be a valuable formative assessment tool for teachers. Each unit includes handouts to support students every time they draw or write. The expectation is that each student will keep these records in a science notebook of some type for reference throughout the unit and to see their ideas evolve. Teachers should organize these handouts into a notebook in the way that best fits their classroom.

Some teachers may have students use an actual notebook, taping handouts into it (and possibly using the notebook in place of some handouts); others may have students use a 3-ring binder or folder; and some may choose to set up a digital science notebook.

In grades K-2, teachers may find it easiest to organize all the unit's handouts in a pronged folder to use throughout the unit, so that all pages are ready when students need them.

In grades 3-5, we encourage teachers not to distribute the handouts to students for the entire unit in advance, as it may give away science ideas that we want students to figure out for themselves.

Developing Scientific Language

Students develop their scientific language through reading science texts and communicating their science ideas in classroom discussions or written communication. Students learn to explain and use scientific words or vocabulary throughout an OpenSciEd unit. These units have been designed to intentionally build student understanding of vocabulary. In the work of the lessons, students make sense of a science idea before discussing the word used to name that idea. For this reason, it is important not to teach this vocabulary all at once before starting a unit (sometimes called "pre-teaching vocabulary"). Rather, teach vocabulary in particular lessons as described in the teacher guide. Through this process, students are also gaining additional practice with the Language standards of the Common Core State Standards.

Two types of words are explained throughout OpenSciEd units: Science Practices and Concepts that build over time and Unit-Specific Science Ideas. Science Practices and Concepts that build over time are words that help students understand scientific practices. These words are necessary for the practice of science in the unit and they are also revisited across units and grades (e.g., *engineer* or *evidence*). The second type of word explained within a given unit are Unit-Specific Science Ideas. These words teach students scientific terms for actions and objects that they have already started to figure out in their investigations. For example, these words are specific to scientific concepts and support sensemaking across a unit (e.g., *collision* or *symmetry*). As new scientific terminology is developed with the class, we recommend that you build a Word Wall of these scientific concept words. Keeping a visual model, or examples if applicable, next to each word can help students recall the concept the word is associated with. Using a Word Wall provides students with a visual cue for the words they are learning in the unit. This helps remind students to use appropriate science terminology in classroom discussions and in writing assignments. Words that explain Science Practices and Concepts and words that explain Unit-Specific Science Ideas are listed in the Lesson and Materials Preparation section of the teacher guide for each lesson. We also include other words in lesson callouts that are not directly related to the unit but may support students in talking about their science ideas (e.g., *accurate*, *amount*, or *location*). These words are explained in lesson callouts found in the margin of the teacher guide.

Supporting Literacy for All Students

The reading and writing tasks included within the program are developed to offer students opportunities to engage with grade-level texts and practice writing skills appropriate for their grade level. However, individual learners' skill levels and needs vary and therefore some students may benefit from differentiated materials and/or instruction to enhance their science learning. In these instances, teachers can use their knowledge of the task and the students to use instructional scaffolds that support students' sensemaking. Literacy scaffolds afford students the opportunity to access grade-level texts and writing tasks alongside their peers.

Instructional scaffolds enhance students' learning and help them work toward mastery of reading and writing tasks. Using scaffolds is a temporary process in which teachers can strategically add or remove supports as students move toward independence with their grade-level literacy skills. For example, students may benefit from using sentence starters to increase their writing output at the beginning of a unit, but as the students gain more practice speaking and writing about unit concepts, this scaffold could be removed. How teachers use literacy scaffolds will depend on the task and students' needs. Teachers are invited to use their teaching experience, expertise, and knowledge about the students to apply the types of scaffolds and support they require.

Scaffolding can occur before, during, and after literacy activities. Scaffolds listed in the following tables can be used during read alouds, scaffolded independent reading, and writing. These scaffolds provide options for increasing and lessening the demands of literacy activities throughout the program. Any of the suggested scaffolds or a combination of these could be applied to support students' science learning across grades K-5. However, it is important to reiterate that teachers should identify and use literacy scaffolds in response to students' needs to engage with texts in the program and complete writing activities.

Scaffolds for Read Alouds

Prior to Reading		
When you observe students who…	You might respond by…	Rationale
benefit from hearing information more than one time	reading the book more than once in different settings (e.g., ELA time, science time)	This scaffold offers multiple exposures to vocabulary and concepts in the book.
During Reading		
When you observe students who…	You might respond by…	Rationale
need additional help noticing relevant information in the text	pointing and gesturing to images and/or parts of the text	Gestures help students understand what part of the text is relevant to the question being posed or idea being discussed. Gestures may be particularly helpful to support students' listening comprehension.
struggle understanding and/or using science words in class discussions	providing additional explanations for unfamiliar words while reading (e.g., explain in words students already know; include images, gestures, or acting it out as needed)	Some students may benefit from additional support in understanding all the words in the text, including words that occur in a book but are not on the Word Wall.
benefit from support with their listening comprehension	modeling comprehension strategies like asking questions, making inferences, or making clarifications by "thinking aloud"	Think alouds support learners' metacognition (thinking about their own thinking). Teachers can think out loud about questions they are having while they read a book to students. All students can benefit from teacher modeling of think alouds, but this may be especially helpful for students who need support in understanding what to think about during a read aloud.

Asking and Answering Questions		
When you observe students who…	You might respond by…	Rationale
benefit from movement to participate in literacy activities	allowing students to respond to teacher prompts during the read aloud with movement (e.g., tell students move to this side of the room if they agree with Zara)	This scaffold enhances the interactive nature of interactive read alouds. This also helps to keep children interested and engaged.
need extra time to think about their responses	waiting for a longer amount of time for students to respond to a given question	Learners need different amounts of time to process a question and formulate a response.
benefit from prompting to share their thinking during large group discussions	telling students to share an answer with a partner rather than answering to the entire class	Some students are reluctant to share their thoughts in large group settings. It may be helpful for them to discuss their ideas with a partner before sharing with the whole group.
say one word or give brief answers to questions	rephrasing what the student says, adding more detail or complexity	This approach honors students' contributions while building on their understanding.
share ideas that are not accurate	rephrasing what the student says in a way that addresses any misunderstandings or inaccuracies, while valuing their contribution	This approach honors students' contributions while building on their understanding. All contributions that students offer are part of their meaning-making process and are valuable to learning. It is important to gently guide student thinking without framing responses as "right" or "wrong." This creates a safe space for all learners to participate actively.

Prior to Reading		
When you observe students who...	You might respond by...	Rationale
struggle with decoding some words	previewing words that are difficult to decode prior to reading the text. Be sure to show the spelling of the word and review letter-sound relationships. For example, tell students that in the word *relationship*, the letters *tion* spell "shun."	This allows students the opportunity to practice decoding words before reading, and increases students' reading fluency and therefore their comprehension as they read.
struggle with decoding many words in the text	using text-to-speech technology to read the text aloud	Students can listen to a text while following along as a way to lessen decoding and fluency demands while supporting reading comprehension.
struggle comprehending science words in the text	previewing complex words and explaining their meaning prior to reading the text	This scaffold supports students' comprehension because they will know the meanings of words when they read the text.
benefit from heavy teacher support to understand what they read	pre-reading the text in a small group	Students gain multiple exposures to the text and they have extra opportunities to comprehend all aspects of the text.
During Reading		
When you observe students who...	You might respond by...	Rationale
benefit from decoding support	assigning students a partner and they read the text together (i.e., dyad reading)	Put students into pairs to read the text. A reader with stronger decoding can be paired with a reader who needs more support, which can benefit both readers.
need additional support with reading fluency	reading the text sentence by sentence. The teacher reads a sentence out loud and the students repeat or echo the same sentence	This scaffold supports reading fluency, confidence, and motivation while reading the text in unison.

benefit from reading comprehension support	putting the students into small groups to discuss the text together. Provide a guiding question for them to stop and discuss.	In a small group, students are able to support each other's comprehension of the text.
benefit from reading comprehension support	modeling comprehension strategies and reading processes like asking questions, making inferences, or making clarifications by "thinking aloud"	Teachers can remind students to try out modeled strategies, before independent reading and while checking in with students as they read. For example, teachers might explain how they reread a text to clarify what is happening in the text.
benefit from teacher support to monitor their comprehension	reading the text paragraph by paragraph and stopping to check for comprehension at each stopping point	This ensures that students can monitor their comprehension as they read. Slowing the pace of reading also provides additional time for students to read the text.

Scaffolds for Writing

Scaffolds for Writing		
When you observe students who...	You might respond by...	Rationale
demonstrate difficulty with letter formation	allowing students to write in whatever form they are able and the teacher writes down what the student says about the science ideas that are drawn or represented on the page	This scaffold ensures that the teacher can decipher the science ideas that the student is trying to communicate. This can be particularly helpful for students who struggle to translate their oral language into written language for a variety of reasons.
demonstrate difficulty with letter formation	using speech-to-text features on student devices (e.g., laptop, tablet) to translate spoken language into written language	For students who recognize letters and spell words conventionally but have trouble with letter formation, speaking their words may be more helpful. This ensures that their ideas are not hindered by the process of forming the print on the page.

demonstrate difficulty with letter formation	offering different types of paper depending on students' individual needs. For example, some students may form large letters and benefit from writing on paper with landscape formatting instead of portrait,	Some students may need to write with a dashed belt-line, or they may benefit from additional writing space.
demonstrate difficulty with letter formation	using technology with a keyboard. Students can also spell words based on how they sound in the moment and edit their work at a later time.	For students who recognize letters and spell words conventionally but have trouble with letter formation, typing their words may be a helpful method of expression.
need reminders for spelling familiar words and word patterns	using classroom resources like Word Walls to cue students on how to spell recurring words in the unit	This offers students additional practice with spelling words that are important for sensemaking in the unit.
primarily rely on drawing pictures to communicate their science ideas	allowing students to draw a representation of their science ideas and say out loud to a teacher/adult what the picture represents. Then the teacher writes words on the page for the student.	This supports students' concepts of print (the understanding that speech can be represented as print). It is also helpful to read what was written back to the student.
primarily rely on drawing pictures to communicate their science ideas but know some letter-sound relationships	encouraging students to add written labels to their drawings and pictures. Students can listen to the first sound in a word and write down its corresponding letter.	This allows students to gain practice forming letters while also providing the teacher more information about students' science thinking.
struggle to write more than a few sounds in a word	encouraging students to listen for every sound in a word and write letters that correspond with each sound	Students can practice mapping letters and their corresponding sounds using this scaffold.
struggle to write in complete sentences	using sentence starters and/or sentence frames to help students generate complete science ideas	This scaffold allows students to focus on writing a response with accurate content in a complete sentence. Some students benefit from sentence starters and/or sentence frames, but these scaffolds

		do not need to be used for all kinds of written language.
struggle to communicate their science ideas using written language	using a planning sheet, outline, or checklist	Students can use planning sheets, outlines, and/or checklists to organize their thinking and apply that thinking to their written language.
benefit from teacher modeling to support their writing	modeling how to write sample texts or sentences to support students' writing, or allow students to look at a preexisting sample text to learn what the writer is doing	Students can use mentor texts to help them format their writing and include important content in their written product.
benefit from reminders for following directions on handouts	underlining important information in instructions for writing tasks	This practice calls students' attention to the most important instructions and helps them include the most important information in their writing.

Using Math to Support Science Sensemaking

The goal of integrating mathematics in the OpenSciEd curriculum is to build a strong base of knowledge to reinforce and strengthen science learning. Mathematics integration is intentional--to help the storyline along, clarify pieces of the puzzle that students are figuring out, or provide students with tools to highlight, analyze, model, and interpret important patterns in the data they are exploring. Mathematical practices along with crosscutting concepts will be employed to develop student understanding of science ideas and deepen science practices. Here are the ways OpenSciEd K-5 units use math to support science sensemaking:

- Leverage student ideas and work to support individual and collective learning.
- Are intentional in the placement of ideas and skills learned in past and current grade levels as well as the standards for mathematical practice.
- Include supports and modifications to ensure all students with a range of fluency in mathematical procedures have access to understanding and application of science content.

The OpenSciEd Elementary curriculum systematically integrates mathematics in the following three ways: math talk, mathematical modeling, and developing data concepts.

Math Talk

Math talk, like science talk, is a critical element of OpenSciEd lessons, allowing deep integration of practices from mathematics to strengthen the learning and doing of science and engineering. Each unit reinforces mathematics content and practice standards as students highlight, analyze, model, and interpret important patterns of the data they are exploring and create their own data displays. Engineering design leverages argumentation as students work on making sense of science phenomena often with and through data, obtaining information from graphical or numerical text, and engaging in ways of talking about and justifying their ideas which supports both science and mathematics goals. We consider supporting the integration of mathematical and computational thinking to promote scientific argumentation a critical component of the OpenSciEd approach (Hufferd-Ackles, et al., 2004; NCTM 2014). Thus, in all curriculum units, we include suggestions for the types of questions that leverage multiple ways of student thinking, stimulate students to think more deeply about and justify mathematical ideas and strategies, and increase student mathematical authority. The following table provides examples of teacher questions connected to specific goals.

Teacher Questions Connected to Specific Goals

Goal	Teacher Support - Purposeful Questions
Eliciting and supporting student thinking and sensemaking	• What did you notice? What are you thinking? • How did you begin working on this? What tools/manipulatives might help? • Does your plan make sense? Why or why not? • What have you found so far? • What tools (e.g., models, measurement, devices, spreadsheets, software) could you use?
Constructing viable arguments	• How did you know? Can you explain that? • How is your answer/model different from ___'s? • What examples could prove or disprove your argument? • So, is what you are saying... (connecting students' ideas to math or science ideas)? • What did we do to help us make that claim?
Developing and using models	• How can you show ___ with a model? How can you clearly show parts of a model? • What are ways to draw, count, or observe what is happening? How do these different representations show different things? • How did you keep track of the data? What patterns did you notice? • How does the graph or simulation describe the situation? • Would it help to create a diagram? Draw a picture? Make a table? • Are there other ways to represent the data? • What are the patterns? How is (variable 1) related to (variable 2)?

Goal	Teacher Support - Purposeful Questions
Analyzing and interpreting data	• What connections (between data and/or the phenomenon) do you see? • Looking at your data table, how can you answer our investigation question? • What data support your claim? • What do you predict will happen? How do you know? • What types of tools can we use to collect and analyze the data? What are the different ways/options to represent the data? • How are these different representations similar and different? Do they provide different information? • What part of the problem/solution does this [point to a particular part of a representation] represent?

Mathematical Modeling

Math models are representations of the world that students will use to understand phenomena and make decisions. These math models describe the important quantitative patterns and relationships embedded in natural systems (Garfunkel & Montgomery, 2016). Standard word problems or even problem solving in school mathematics curricula often do not model realistic problem situations for problem solving, whereas math modeling presents students with realistic problem-solving experiences requiring strategizing, using prior knowledge, and testing and revising solutions in real contexts. Math modeling is an iterative problem-solving process in which math is used to explore, explain, and make sense of real-world problems and specifically to strengthen students' exploration and explanation of the storyline. Students will engage in mathematical modeling in every unit. A modeling approach naturally integrates disciplines, as modeling allows students to engage in both scientific and mathematical practices as well as statistically learn science and mathematics concepts (e.g. NGA Center & CCSSO 2010). Students will construct mathematical models (e.g., data, mathematics, and computing) as part of scientific investigation, developing and using multiple mathematical models to explain and predict different aspects of a phenomenon.

- **Identify the Problem.** Modeling problems are open-ended. As students examine the phenomenon, they will be asked to define what it is they would like to find out.
- **Make Assumptions and Identify Variables.** Since it is impossible to account for all the important factors in a given situation, the students as modelers will need to make choices about what to incorporate in their representation of the real world. Making assumptions and predictions helps reveal the variables that could be considered and also reduces the number of them. Within this process, relationships between variables will emerge based on observations.
- **Do the Math.** Examining the relationship between variables will allow for possible solutions to be found.
- **Analyze and Assess the Solution.** As students consider the results and insights gained from the model, ask if their answer makes sense.

- **Iterate.** Going through the unit, student models should be refined and the process can be repeated to improve how the model represents the phenomenon under investigation.
- **Implement the Model and Report Results.** A clear report on the model and its implementation makes the model understandable to others.

Developing Data Concepts

Data and statistical literacy is critical to understanding the world around us. Measures that describe data with numbers are called statistics. Doing data is a different process from doing mathematics. Mathematics is about numbers and their operations; working with data also includes numbers, but data are always numbers with a context. Furthermore, data and statistical thinking entails understanding and describing the variability within the data that occurs. The OpenSciEd curriculum provides students with frequent opportunities to learn the practices of creating, analyzing, and interpreting data.

Assessment

The goal for assessment in OpenSciEd Elementary is to provide students with opportunities to share their ideas, experiences, and ways of making sense of the world and for these ideas, experiences, and sensemaking strategies to be welcomed, valued, and used to support ongoing learning. When this philosophy toward assessment is enacted in classroom communities that have built norms and routines to invite students to make their thinking visible and use this thinking to help make sense of science phenomena, students can see how their ideas drive science learning. All OpenSciEd Elementary curriculum units have assessment opportunities woven throughout the lessons to support teachers in being responsive to students' ideas and to support students in building their science understandings. These assessment opportunities encourage multimodal communication such that students have many different ways of demonstrating their ongoing sensemaking. Teaching tips and other educative features include prompts and questions to increase participation for traditionally minoritized learners within the whole class and cooperative learning groupings.

There are five main assessment opportunities in OpenSciEd Elementary units: (1) pre-assessment; (2) formative assessment (including both ongoing formative assessment and key formative assessment opportunities); (3) summative assessment; (4) self-assessment (called self-reflection); and (5) peer assessment (called peer feedback).

Pre-Assessment

Pre-assessment in OpenSciEd Elementary includes multiple opportunities for gathering information about students' incoming/initial ideas and experiences (i.e., pre-assessment information). As opposed to a specific test, quiz, or other traditional assessment, these opportunities are embedded into activities where students are making sense of the phenomenon in Anchoring Phenomenon Lessons.

Pre-assessments help to determine what incoming ideas and experiences students bring to the unit. These formative tasks are linked to the unit- and lesson-level learning goals as well as the unit-level phenomenon, design problem, and/or driving question. Pre-assessment opportunities include collective and/or individual sensemaking moments. Collective opportunities for pre-assessment will include sensemaking in both small and large group discussions, drawings, and models. Teachers keep track of students' ideas, experiences, and preliminary explanations in Notice and Wonder charts associated with the anchoring phenomenon. Teachers should accept all student ideas and wonderings and record these on the chart to track and return to throughout the unit. There are also opportunities for individual pre-assessments where students can record their ideas in artifacts such as models or a Driving Question Board.

Formative Assessment

Formative assessment practices (i.e., eliciting, identifying, interpreting, and responding to students' ideas and experiences) are crucial for supporting students' scientific sensemaking and promoting equity in science classrooms (e.g., NASEM, 2022; Philip & Azevedo, 2017). In addition, formative assessment can "...contribute both to metacognition and identity development because [it] involves students in activities to internalize the criteria for judging quality work, take responsibility for evaluating and seeking to improve their own work, and in so doing take on the role of disciplinary expert" (Shepard, Penuel & Pellegrino, 2018, p. 28).

Each lesson has multiple opportunities for formative assessment. Formative assessment opportunities are aligned with one of the three-dimensional lesson-level learning goals. These opportunities include prompts (verbal, gestures, written) embedded into activities that allow teachers to "quickly" determine whether students are building understanding. These prompts are included in tables that have ideas that teachers should look for and listen for in student responses. There are also suggestions for follow-up questions or prompts for teachers to use to support students' ongoing learning. In addition, at the beginning of each lesson, there is a table that provides information for teachers on how to use the information that they elicit to best support learning.

Feedback Suggestions Embedded into Teacher Guide[2]

If a student response...	The feedback may invite students to...
Shows beginning ideas and needs support in connecting ideas	• Revisit their Growing Ideas chart to connect more of what they know and can do to build a more coherent explanation of the phenomenon. • Ask students to consider how their own ideas link to investigations they have conducted and models they have constructed. • Consider possibilities about how two ideas that have been explored might be connected.
Shows developing but not a fully secure understanding	• Problematize students' existing thinking by posing a question that could help them identify a gap in their own thinking. • Consider an alternative point of view that would lead them to pose new investigative questions. • Invite them to integrate more from the investigations they have experienced and models they have constructed into their explanations or solutions.
Shows a secure understanding of the anchoring phenomenon	• Explore further connections to everyday life and students' communities. • Explore whether their knowledge generalizes to cases that are not obviously connected to the anchoring phenomenon.

[2] Modified from OpenSciEd High School

Summative Assessment

Each unit includes at least one opportunity to summatively assess students' learning. Summative assessment opportunities provide students with the ability to synthesize what they have figured out through investigations and informational texts and often occur in Putting Pieces Together Lessons. Summative assessment opportunities take several different forms depending on the lesson. In grades K-2, there are often ongoing observational opportunities to summatively assess students' sensemaking. Teachers are provided with a Following Student Sensemaking sheet, where they can keep track of students' ideas aligned with the dimensions associated with specific performance expectation(s) across several lessons. Using a rubric, teachers can prompt students to provide evidence of their sensemaking throughout lessons to ensure that students reach a "secure" level of sensemaking aligned with unit performance expectations. These can include both verbal and written prompts.

There are also opportunities for "checkpoint" assessment tasks to determine whether students met the learning goals for the unit. These three-dimensional tasks may be embedded in lessons or use a closely related (but separate from the unit) phenomenon, problem, application, extension, or context. Summative assessment opportunities are three-dimensional and include a leveled rubric that teachers can use to evaluate student work and provide feedback to students.

Example Rubric for Summative Assessment Opportunities

Beginning (B)	Developing (D)	Secure (S)
Response draws on everyday ideas/ experiences and ideas encountered/observations made in investigations.	Response draws on everyday ideas and ideas encountered in investigations **and begins to connect them together to explain <u>some aspects</u> of the phenomenon.**	Response draws on **elements from all three dimensions** along with everyday ideas, to support an explanation for **the phenomenon.** Where appropriate, students may begin to apply explanations/generalize beyond the phenomenon.

Self- and Peer Assessment

All OpenSciEd units have opportunities for students to develop and use criteria to examine their ongoing sensemaking (i.e., self-assessment) and to support their classmates in advancing their learning (i.e., peer assessment). The materials do not use the language of self- and peer assessment with students as the focus is on supporting students in advancing their sensemaking rather than in judging. In lessons, teachers will work with students to identify criteria for evaluating specific tasks (e.g., models, explanations) and may create a list that students can use, such as a Gotta-Have-It Checklist. Using the list of criteria, students may examine their own work and make revisions and/or collaborate with a partner to provide feedback such that partners can revise and improve their work together.

Incorporating Trauma-Informed Approaches

Many school districts across the country have invested in professional development and interventions to help ensure trauma-informed educational experiences for students. Trauma-informed approaches and strategies in the classroom promote a safe and positive learning experience for all students and enhance safety for students who are entering the classroom with a history of trauma.

Two-thirds of children report experiencing at least one traumatic event by age 16 (SAMHSA, 2023). Sometimes students with a history of trauma can experience anxiety and emotional dysregulation when reminded of those traumatic experiences (NCTSN, n.d.). For students who have a trauma history or are prone to anxiety, discussing certain topics that are relevant to their work in science, such as extreme weather or natural hazards, can be difficult or worrisome.

SAMHSA (2014) has identified guiding principles for a trauma-informed approach and these principles have been widely accepted and adopted (Kouslouski & Chafoles, 2022). Of these, in the context of an elementary classroom discussion, the principles of safety, trustworthiness and transparency, peer support, and collaboration are particularly salient and inform the suggested strategies to follow.

Strategies for When Students Share Potentially Traumatic Experiences

A connected, collaborative classroom culture helps develop and maintain healthy classroom relationships. In an elementary classroom, this often involves students openly sharing their experiences and thoughts connected to the lesson. For example, when the class is investigating weather, students may share stories about traumatic events they have experienced or heard about secondhand. When this occurs, teachers can respond in a way that continues to encourage students to connect the lesson to their own lives and discuss that with their class, support students when they share a distressing event or thought, and still stay within the structure and routine of the lesson to accomplish instructional goals.

The three steps of **Be Curious**, **Validate**, and **Thank the Student** provide a repeatable "recipe" that teachers can use in a variety of group discussions to accomplish these goals. Modeling this structure of responding to personal stories creates a predictable routine that students will learn to expect and provides boundaries around how to share these personal experiences in a group discussion, two key skills in trauma-informed social-emotional learning practices (Minahan, 2019; Transforming education, n.d.). This approach is aligned with the classroom agreement of "We look, listen, and respond to each other's ideas," with the following three steps offering a consistent strategy that teachers can use to respond to students who are sharing their experiences.

1. **Be curious.** Students are amazingly resilient. **What defines an event as traumatic is the student's response to and experience of the event, not the event itself** (Berkowitz, 2023). Helping students

accurately label and express feelings is a key skill for social-emotional learning (Wigglesworth et al., 2019). When a student is sharing an experience, it is important to be curious about how they felt about it and provide support to help them accurately label those feelings.

Instead of...	Try...
That must have been really scary for you.	What was that like for you?
I would have felt really worried if that happened.	Can you use our class feelings wheel to share how you felt?
You must have been so scared!	I can imagine having a lot of feelings about that.

Having a simple feelings wheel in use in your classroom can be a helpful tool to provide scaffolding to support students in accurately labeling and communicating their feelings.

2. **Validate.** Validation begins with listening to what the student shares, reflecting back a quick summary, and closing with a statement that you understand why the student may have experienced it that way. Here are a few examples:

If the student says...	You might say...	
	Summary	Statement of understanding
I felt really scared during the tornado warning yesterday.	It sounds like you and a few other students were really scared when you heard the warning.	It makes a lot of sense why that would be scary--I know some other people who felt scared too.
My grandma and grandpa were in Florida for the hurricane.	So your grandparents experienced that weather.	I can see why you thought of that during our discussion today.
I run out of the room when scary weather comes on the news.	If you see extreme weather on the news you get right out of there.	Sometimes I see things on the news and want to turn it off, too.

3. **Thank the student.** Thanking the student for sharing their thoughts and experiences conveys the message that connecting their life experience and voice to the lesson is valued and appreciated. These are key messages for a trauma-informed classroom experience. You might say
    - Thank you for sharing that with us.

- I can see you are really thinking about our discussion today. Thanks for sharing your idea.

In some situations, a teacher may also choose to **follow up** with a student after a large group discussion to see if additional supports are needed. Connecting students to caring adults is a key way to address or mitigate the impact of trauma (CDC, 2023), so follow-up may consist of a quick check-in or ensuring the student can identify a caring adult they can talk to, such as a parent/guardian, another family member, a neighbor, or a member of their faith community.

If a student is sharing their experience in class but it may be stress inducing or derailing for the class to hear, use the same framework provided above with an emphasis on validation and thanking the student for sharing versus asking questions. After the lesson, find a time to check in with the student privately to determine if they have support in place and someone they can talk to. If the student is emotionally dysregulated (e.g., crying, shaking, appearing disconnected/dissociating, verbalizing being upset), send them to the counseling office for additional support.

If a student appears to display a trauma response (e.g., appearing disconnected/dissociating, causing disruption to the lecture, having trouble managing emotions, increasing activity level, having somatic complaints, being avoidant, being easily startled, exhibiting clingy behavior), but is not sharing with the class, find time to check in with them after the lesson one-on-one. Talk to the student about what you observed and let them know you are there if/when they need to talk.

Additional Strategies

Many schools have adopted social-emotional learning (SEL) curricula or approaches to explicitly teach skills to support emotion regulation and healthy relationships (CASEL, 2003). Trauma-informed approaches integrated with SEL work toward ensuring that all students, including those who have experienced trauma, have the skills, knowledge, and attitudes to regulate emotions and be productive, engaged learners (Pawlo et al, 2019; Transforming Education, n.d.). Often classrooms and schools have existing systems, strategies, and skills in place to support trauma-informed discussions and help students build important social-emotional learning skills such as identifying emotions, perspective taking, communication, and relationship building (Greenberg, 2023).

Teachers can reinforce and coach the use of skills taught within your school's or classroom's social-emotional learning curriculum. Classroom discussions often provide an opportunity to help students begin to implement skills such as identifying emotions, recognizing strengths, stress management, relationship building, and solving problems. This can involve inviting students who have mastered those skills to model them for other students who are working on using them.

Classroom agreements can provide support and a familiar structure to help students frame these conversations.You can explicitly connect how the agreement to look, listen, and respond to each other's ideas shows up in science work and other group discussions.

While resources available within schools vary, you can also reach out to your school psychologist, principal, colleagues, and school counselors for additional ideas to increase the social-emotional skills of all the students.

Compassion Fatigue

When students share their traumatic experiences it is common for this to impact you as well, especially after numerous stories and/or vivid details have been shared. Compassion fatigue or secondary traumatic stress involves being overwhelmed by others' traumatic experiences and can impact someone physically, mentally, and emotionally. Watch out for signs such as irritability, difficulty concentrating or planning, feeling numb, intense feelings and intrusive thoughts, and difficulty sleeping. It is important to be mindful of this and to take care of yourself and your colleagues. Allowing yourself to feel the emotions, taking care of your own body and wellness, and experiencing connection are key to combating compassion fatigue.

Additional Resources About Trauma-Informed Approaches

Osher, D., Guarino, K., Jones, W., & Schanfield, M. (2021). Trauma sensitive schools and social and emotional learning: An integration. University Park, PA: Edna Bennett Pierce Prevention Research Center, The Pennsylvania State University. Retrieved https://www.air.org/sites/default/files/2021-09/Trauma-Sensitive-Schools-and-SEL-Integration-Brief-June-2021rev.pdf.

Transforming Education. (2019). Trauma-Informed Social Emotional Learning Toolkit. https://transformingeducation.org/resources/trauma-informed-sel-toolkit/

Gonzales, Jennifer. (2017). Three-step approach to validation. Retrieved https://www.cultofpedagogy.com/magic-of-validation

Resilient educator (2018). Essential trauma-informed teaching strategies for managing stress in the classroom (and virtual classrooms). Retrieved https://resilienteducator.com/classroom-resources/trauma-informed-teaching-tips/

Sweetman, N. (2022). What is a trauma-informed classroom? What are the benefits and challenges involved? Frontiers in Education, 14. https://doi.org/10.3389/feduc.2022.914448

Universal Design for Learning (UDL)

The Universal Design for Learning (UDL) Guidelines are a tool that can be used to design learning environments that are **accessible** and **challenging** for all learners (CAST, 2018). The framework embraces curriculum development that works for everyone--not with a single, one-size-fits-all approach, but one that considers the strengths and needs of the broadest possible range of learners from the beginning. CAST founders adopted the term *universal design for learning* because UDL guides educators in designing learning spaces that not only are accessible for a range of different abilities, strengths, and needs, but also actively engage learners, activate thinking, and scaffold deep understanding. OpenSciEd units and lessons are designed with three guiding principles to provide multiple pathways for student learning, by using: (1) multiple means of engagement, (2) representation (presentation), and (3) action and expression, to reach and engage more learners. OpenSciEd units offer built-in supports for teachers to highlight student assets and agency and to address potential barriers to learning for their local student population.

You may also want to review the strategies described in the Additional Accessibility Resources document.

	Provide multiple means of **Engagement**	Provide multiple means of **Representation**	Provide multiple means of **Action and Expression**
Access	Provide options for recruiting interest (7) 7.1 Optimize individual choice and autonomy 7.2 Optimize relevance, value, and authenticity 7.3 Minimize threats and distractions	Provide options for perception (1) 1.1 Offer ways of customizing the display of information 1.2 Offer alternatives for auditory information 1.3 Offer alternatives for visual information	Provide options for physical action (4) 4.1 Vary the methods for response and navigation 4.2 Optimize access to tools and assistive technologies
Build	Provide options for sustaining effort and persistence (8) 8.1 Heighten salience of goals and objectives 8.2 Vary demands and resources to optimize challenge 8.3 Foster collaboration and community 8.4 Increase mastery-oriented feedback	Provide options for language and symbols (2) 2.1 Clarify vocabulary and symbols 2.2 Clarify syntax and structure 2.3 Support decoding of text, mathematical notation, and symbols 2.4 Promote understanding across languages 2.5 Illustrate through multiple media	Provide options for expression and communication (5) 5.1 Use multiple media for communication 5.2 Use multiple tools for construction and composition 5.3 Build fluencies with graduated levels of support for practice and performance
Internalize	Provide options for self-regulation (9) 9.1 Promote expectations and beliefs that optimize motivation 9.2 Facilitate personal coping skills and strategies 9.3 Develop self-assessment and reflection	Provide options for comprehension (3) 3.1 Activate or supply background knowledge 3.2 Highlight patterns, critical features, big ideas, and relationships 3.3 Guide information processing and visualization 3.4 Maximize transfer and generalization	Provide options for executive functions (6) 6.1 Guide appropriate goal setting 6.2 Support planning and strategy development 6.3 Facilitate managing information and resources 6.4 Enhance capacity for monitoring progress

Source: Modified from CAST (2018), Universal Design for Learning Guidelines, Version 2.2, graphic organizer found at http://udlguidelines.cast.org

The UDL framework is organized both horizontally and vertically based on neuroscience research regarding how human beings learn. The neuroscience research shows that learning involves a multistep process, a trajectory to support deep understanding. Horizontally, the UDL framework is organized to support student engagement in the learning context or environment and build deep understanding during the process of learning. The "access" row suggests ways to increase access to learning goals by recruiting interest and providing options for perception and physical action. The "build" row suggests ways to develop skills in effort and persistence, language and symbols, and expression and communication. The "internalize" row suggests ways to empower students through self-regulation, comprehension, and executive function (CAST, 2018).

Vertically, the Guidelines are "organized around three principles, which are aligned with three networks in the brain that involve the learning processes:

- Multiple means for *engagement* of students (corresponding to the *affective* network--the *why* of learning)
- Multiple means of *representation* of information for students (corresponding to the *recognition* network--the *what* of learning)
- Multiple means for *action and expression* by students (corresponding to the *strategic network*--the *how* of learning)" (Ralabate, 2016, pp. 4-5)

The UDL Guidelines were created for the purpose of developing "expert learners" who are purposeful and motivated, resourceful and knowledgeable, and strategic and goal-directed (CAST, 2018).

Engagement

Engagement is at the core of all learning experiences and "learners differ markedly in the ways in which they can be engaged or motivated to learn... there is not one means of engagement that will be optimal for all learners in all contexts; providing multiple options for engagement is essential" (CAST, 2018). OpenSciEd units use an anchoring phenomenon that is complex and interesting to both stimulate and maintain student engagement throughout each unit. In the UDL framework, teachers can foster student engagement by recruiting student interests, supporting sustained effort and persistence, and providing options for students to self-regulate. Students generate questions that they are interested in answering, allowing them to set their own purposes for learning. Classes repeatedly revisit the anchoring phenomenon and guiding questions in discussions and on their Growing Ideas charts, maintaining student investment in the work of figuring out the phenomena. Individual student progress is recorded in their science notebooks, and class progress is displayed through charts and visuals in the classroom, providing constant feedback to students about what has been accomplished through their work.
The units provide guidance to teachers in developing a safe space for students to share and build on ideas through developing and revisiting classroom agreements. Teachers may choose to use optional peer and self-assessment resources that are provided to support students' capacity for reflection.

Examples of the Engagement Principle

In OpenSciEd units, guidance for the Engagement principle is provided for teachers within a variety of callout box labels (e.g., *Broadening Access, Teacher Tip, Community Connection*). These callout boxes provide supplemental guidance for using classroom agreements and opportunities for choice to increase student engagement. A mini-lesson for establishing classroom agreements is included in every grade level's first unit, and opportunities to revisit, reflect on, and revise classroom agreements are embedded throughout the lessons in every unit.

Access - Recruiting Interest

One of the best ways to recruit students' interest in the content is by creating a safe classroom environment, where the curriculum connects to their lived experiences and provides opportunities for students to have a choice in how they learn. Learning new content must build from what students know and have experienced. The following

Broadening Access callout box provides an example of teacher support in helping the students see themselves in the curriculum:

> *Provide multiple means of engagement by asking students how they have used magnets in their lives to solve a problem or create something. This helps optimize the relevance, value, and authenticity of the focal science idea for students.*

Build - Sustaining Effort and Persistence

When students are given opportunities to understand the learning goal, to work within a collaborative community, to receive mastery-oriented feedback, and to rise to challenges with tools and support, they will be building their capacity for sustained effort and persistence in learning. This *Broadening Access* callout box provides an example of ways teachers can make the learning goal more visible to students and why it matters:

> *Navigation moves help students see connections from one lesson to another. They also help students understand the purpose or goal of the lesson. Support engagement and persistence by making salient what students want to figure out. Display the students' goal on a whiteboard or other visible space. Display it in multiple ways so that it is accessible to all learners.*

Internalize - Self-Regulation

Engagement can be increased by providing students with options for self-regulation. The following *Broadening Access* callout box is in each unit's Lesson 1 and introduces and explains the Scientists Circle construct as a support for students to develop self-assessment and reflection skills:

> *Having students sit in a Scientists Circle, which is a circle where they can face one another, is an important tool for developing students' agency in their learning as they take stock of what they have figured out and decide where they need to go next. It is important to allow space for all students to share their own experiences and stories of how they connect with science in their everyday lives. Even if students' ideas do not seem related, use follow-up responses to give all students space and time to be included and valued in the discussion.*

Representation

OpenSciEd units require students to use science concepts to figure out explanations or solutions to natural phenomena. However, what is provided or presented to students can enhance or deter a learner's ability to engage in rich discussion and thinking. Neuroscience research indicates that learners remember about 10% of orally presented information; however, if you present information orally with a nonlinguistic (i.e., visual or sensory) resource, learners recall about 65% of the information (Ebert et al., 2011). Representation focuses on providing multiple means of representation to build knowledge and comprehension with the intended goals of learning. Multiple representations are meant to provide different access and entry points so all students are growing as learners and reaching toward the same goal. OpenSciEd units provide multiple means for students to access information; lessons incorporate models, data tables, texts, graphs, videos, and discussions. The units and lessons are carefully designed so that all materials incorporate accessibility features (e.g., alternative text, alternative representations, video captions, described videos, descriptive transcripts, color contrast) that foster the use of multiple access and entry points and appropriate representations that will accentuate the assets and mitigate the barriers of diverse learners as they work toward a rich understanding of science.

Examples of the Representation Principle

In OpenSciEd units, guidance for the Representation principle is provided for teachers within a variety of callout box labels (e.g., *Broadening Access, Teacher Tip, Literacy*). These callout boxes provide supplemental guidance for multiple access points for learning while maintaining the goals of students' figuring out science ideas.

Access - Perception

Providing alternative representations for visual and verbal information can increase student access to the materials. This *Teaching Tip* callout box provides an example of how teachers can support multiple means of representation by sharing information in more ways than verbal expression alone:

> *As students share similarities and differences in their models, invite a volunteer or two to describe differences by holding up and pointing to their models or sliding them under a document camera. The purpose of comparing the two models is to notice and celebrate our developing understandings.*

Build - Language and Symbols

To support students' understanding of scientific language, teachers can provide explicit opportunities in the lesson to clarify vocabulary, symbols, syntax, mathematical notation, etc. The following *Literacy* callout box is an example of how to use multiple media as access points to support students' scientific language development:

> *Help students connect new vocabulary, like "investigation", to what they have already learned through their explorations. For example, you might point out how students investigated when they watched the videos, built their own initial sculptures, and looked at other examples from home.*

Internalize - Comprehension

Multiple means of representation can help students construct a deep understanding of the content. Teachers can use the guidance built into the OpenSciEd curriculum to activate background knowledge, highlight patterns and big ideas, guide information processing, and maximize generalization through the use of representations. The following *Teaching Tip* callout box provides teacher support for creating explicit opportunities for students to make connections to their previous knowledge and between key ideas in the unit:

> *During the read aloud, connecting to previous chapters read and previous experiences helps children deepen their understanding of the text and the unit. Pause throughout to provide children opportunities to think and discuss the questions you are asking. You may also wish to ask them if this read aloud reminds them of any personal experiences or if they have questions.*

Action and Expression

The goal of the Action and Expression principle is to ensure that learners can fully communicate what they know and to support strategic planning through varied forms of action or expression. The OpenSciEd units provide opportunities for students to develop strategies (e.g., self-reflection, planning, goal setting) and skills (e.g., speaking, writing, assembling physical models) that enable them to plan, organize, initiate, coordinate, and monitor purposeful actions in the environment. The units contain several features that support students to plan, organize, and evaluate their own learning across the unit. For example, each unit identifies opportunities for self-assessment, and often includes student-facing tools like discussion protocols and self-assessment rubrics that support students to plan for and self-evaluate their learning and growth across the unit. Additionally, the units provide multiple means for students to express their developing understandings and to show their learning. For example, the science notebook is a tool for students to record their thinking and use words, pictures, and symbols in ways that help them make sense of the investigations and science ideas that emerge. Further, on formative and summative assessments, students are asked to write or draw their current thinking, allowing them to show their learning in a variety of formats.

Examples of the Action and Expression Principle

In addition to the support built within the curriculum, callout boxes that provide guidance for the Action and Expression principle can be found within the OpenSciEd units under a variety of labels (e.g., *Broadening Access, Teacher Tip, Science and Engineering Practice*). These callout boxes provide supplemental guidance to teachers in supporting students to choose the way they express their thinking as they figure out science ideas.

Access – Physical Action

Access to learning can be increased through alternative ways to interact with physical manipulatives or through specific tools and technology. This *Broadening Access* callout box provides an example of alternative options to engage with a physical investigation that can be used to support students:

> *If you have a student(s) with a disability related to mobility, you will need to adjust this exploration to ensure their equitable participation. Work with the student's case manager as needed, but ideas for providing multiple means of engagement include using a hand instead of a foot to kick the ball, using a hockey stick to reach the ball to push it, or rolling the ball down a ramp to "kick" it to the partner.*

Build – Expression and Communication

Using scaffolded tools for flexible expression and communication can help students to build their fluency in grade-level content. The following *Teaching Tip* callout box guides the teacher in how to use the If/Then sentence structure tool to support students in constructing their ideas about the science in the investigation:

> *Students practice making their first If/Then statement as a class with guidance from the teacher. It may help to break this statement into the following parts: (1) the type of extra force used, (2) the shape of the balance point used, and (3) what type of movement occurs. Students can then use this statement as a model when*

they write their own statement in the next activity.

Internalize - Executive Functions

Teachers can provide multiple means of expression and action by guiding students in performing executive functions like goal-setting, planning investigations and progress toward goals, organizing information, and monitoring their learning. This *Teaching Tip* callout box provides guidance for supporting students in organizing, reflecting on, and communicating their data:

> *These moments for self-reflection are important for students to synthesize information in ways that make sense to them, while also practicing how to communicate that information, even if it is for their own use. We suggest that if you choose to review students' Growing Ideas charts, you do so only to see where students are in their learning, rather than using them as a graded assessment.*

UDL and Differentiation Work Together to Support Student Learning

OpenSciEd units are designed to use the principles of Universal Design for Learning to provide equitable and accessible learning throughout. However, we acknowledge that teachers will still need to find ways to modify activities in the materials to better fit students' learning needs or the needs and resources of the classroom. There are many ways differentiation occurs in classroom settings. Teachers can address the students' diverse needs in terms of student readiness, interest, and special learning needs and can make adjustments to the content, the learning processes, and the student products that result from a learning experience (Tomlinson & Allan, 2000). OpenSciEd units are also designed with differentiation in mind, allowing teachers to adapt the materials as necessary without diminishing the learning experiences for students. Teachers can find differentiation guidance within the teacher guides in these types of callouts:

- *Broadening Access* callouts focus on moments during instruction in which a certain population may benefit from a particular strategy--for example, supporting language development for emergent multilingual learners, providing extended learning opportunities or readings for students with high interest, providing specific strategies for students with special learning needs.
- *Teacher Tip* callouts provide more specific instructions to teachers about how to make a learning activity successful based on students' needs. These callout boxes provide a variety of instructions to modify the timing, grouping, or resources for a particular activity.
- *Literacy* callouts provide support in where, why, and how literacy practices are being used to support science sensemaking. These callout boxes provide instructions for scaffolding students' use of language and vocabulary, as well as making connections with how scientists use these practices.
- *Science and Engineering Practice* callouts highlight ways that science and engineering practices are being used in the lesson and provide opportunities for students to practice developing those skills.
- *Community Connection* callouts focus on how to connect the curriculum to the students' communities outside of the classroom. These callout boxes provide instructions for how to recognize and have students bring in ideas from different communities.

- *Crosscutting Concept* callouts highlight ways that crosscutting concepts are being used in the lesson and provide opportunities for students to practice developing those skills.
- *Math Support* callouts provide support in where, why, and how math is being used to support science sensemaking. These callout boxes provide instructions for scaffolding students' use of tools and math concepts, as well as providing extended learning opportunities with patterns and mathematical representations.

Additional differentiation strategies are available in the math and literacy sections of this handbook. Also, please see the Additional Accessibility Resources document for specific strategies to support all learners in using OpenSciEd Elementary materials.

Conclusion

The UDL Guidelines informed the design of the OpenSciEd instructional materials to minimize barriers and create pathways for diverse learners. Diverse learners include those who are culturally and linguistically diverse, have a disability, are emergent multilingual learners (EMLs), and/or are considered gifted and talented. However, all learners benefit from UDL. Learner variability is the norm in every classroom. Each individual student can be recognized as part of multiple groups and has unique characteristics specific to that individual. The routines and strategies built into the units optimize student choice and agency and provide multiple pathways to maximize deep learning for all students. Furthermore, the callout boxes provide additional strategies that teachers can use to adapt activities and modify the units to better meet the needs and leverage the resources of specific learners.

Supporting Multilingual Students

Who are multilingual students?

We intentionally use the term *multilingual students* because it is asset-oriented, highlighting students' multiple communicative resources and practices and their abilities to use named language(s) (e.g., Cantonese, Spanish, Arabic) as part of a broader repertoire that includes English (González-Howard, Suárez & Grapin, 2021). An estimated 5 million students, or 10% of the total student population in the United States, are multilingual (NCES, 2020). However, this is likely an underestimation because these numbers reflect only students who have been legally identified as English Language Learners (ELLs) and thus are entitled, through state and federal laws, to academic coursework with specialized support to help them reach certain thresholds for English proficiency (Grapin, 2021). Multilingual students are not a uniform student group. The term *multilingual students* captures an extremely diverse group of students that vary among many factors including (but not limited to) race, family and schooling backgrounds, migrational histories, generational status in the United States, named languages they know and speak, English language proficiency, and the types of programmatic supports they might be receiving (or have received) in school to address their English language development (e.g., sheltered English instruction, pull-out programs, ESL programs, bilingual classroom aids) (NASEM, 2018). Multilingual students bring into our classrooms multiple language-related resources and practices, as well as rich lived experiences and ideas about how our natural world works. This is a student group who has historically received unequal access and inadequate instruction in science, and it is critical that teachers notice, value, and leverage their multilingual students' contributions in the classroom. Doing so will only enrich the classroom community's science learning experiences (González-Howard & Suárez, 2021).

Why is it important to focus on multilingual students within current reform standards?

The vision set forth by the *Framework for K–12 Science Education* (National Research Council, 2012) calls for major shifts in the teaching and learning of science, where students learn in the context of puzzling phenomena and engage in authentic science and engineering practices (SEPs) as they seek to make meaning of these phenomena. The emphasis on SEPs builds on prior reforms that used the concept of "inquiry" to highlight that students should actively generate knowledge. However, previous conceptions of what "inquiry" in science meant ranged greatly from carrying out investigations to engaging in "hands-on" experiences (another catch-all phrase used in science education). SEPs more clearly articulate the various ways that students can collaborate with peers to develop understandings of natural phenomena or to solve design problems (Bang et al., 2017). To meaningfully engage in these SEPs, students must use language in increasingly complex ways (González-Howard et al., 2023). For example, students are now expected to construct explanations and engage in argumentation from evidence, both of which require the use of various linguistic (e.g., speaking and writing) and multimodal (drawings, graphs, models, gestures) forms of communication (Grapin, 2019; Suárez, 2020). Adding to this complexity, this language use occurs in real time as students take in their peers' ideas, make sense of them in light of their own thinking, and respond in ways to further the groups' understanding of the topic being explored. These language demands present opportunities for multilingual students to tap into and expand upon their language-related resources and practices (González-Howard et al., 2023; Lee & Stephens, 2020), but could also bring about potential challenges if narrow views of language are privileged within the classroom community (e.g., assessments being formatted so that students can only engage in them through spoken and written English) (Fine & Furtak, 2020).

How do students use language for scientific sensemaking?

A major function of language is to provide a way for us to make sense of the world and to share that sensemaking with others; in other words, to use language for scientific sensemaking (González-Howard et al., 2024; Lee & Stephens, 2020). In science, we make sense of phenomena using both linguistic and multimodal forms of communication, which provide learners of science with many different ways to access new content and share how they are making sense of these phenomena (Grapin, 2019). When considering what these language demands mean for multilingual students, the tendency has been to focus on students' English language development first, believing a certain threshold of English is needed to learn and do science. This perspective has led to inequitable science learning opportunities for multilingual students, with these students being removed or kept from certain experiences until reaching particular English proficiency levels (González-Howard & Suárez, 2021). Science learning and language development mirror and support one another, and should not be viewed as two separate processes. An example of a common instructional practice that does not integrate language and science has been to focus on pre-teaching vocabulary at the start of a science unit. Instead, research shows that students should be exposed to authentic contexts to explore science ideas and attain new vocabulary as they develop their own understandings of science concepts and processes (Haverly, Hossein & Richards, 2021).

Phenomenon-driven science instruction--which is at the heart of the instructional model guiding OpenSciEd Elementary science units--provides multilingual students with authentic contexts and purposes for which to use their developing language-related resources and practices, while also supporting students in making sense of the phenomenon being explored. As the content students learn becomes more sophisticated, so do the ways students use language to make sense of it and to communicate ideas about it (Lee & Stephens, 2020). It is important to understand the ways that all language-related resources and practices are used for scientific sensemaking to ensure that all students, particularly multilingual students, have equitable learning experiences in the science classroom (Grapin, 2019;). Understanding the role of language in sensemaking includes valuing the assets that multilingual students bring as knowledge forms and features unique to each SEP. For example, when engaging in the practice of argumentation, students generate arguments in the structural form of a claim substantiated with evidence and reasoning, all of which students can express linguistically (e.g., written or spoken words) as well as multimodally (e.g., graphs capturing their investigation findings). Multilingual students have many meaning-making resources and practices, which teachers can learn to better notice, acknowledge, and value in their classrooms (Bang et al., 2017). Focusing on these assets can allow teachers to leverage students' prior conceptions and knowledge about science concepts being learned. This helps make learning experiences more meaningful, positioning multilingual students as valuable contributors to the classroom community's knowledge construction work. Thinking about potential challenges that multilingual students might face can allow teachers to proactively come up with solutions to better support students' needs.

How does OpenSciEd Elementary support multilingual students?

There are numerous ways that OpenSciEd Elementary materials support multilingual students. Some of these supports are embedded within the curricular design and pedagogy that are at the heart of this program's instructional model. Other supports are evident through educative features included in the teacher guides; these features are educative in that they address teacher learning (Davis & Krajcik, 2005), in this case around ways to best teach science with multilingual students.

The curricular design of OpenSciEd Elementary, and the pedagogy promoted by the materials, grounds students' learning experiences in real-world phenomena. For instance, a 2nd grade unit on properties of matter is anchored in students figuring out, *How can we design a new toy?*. In this approach, students are not just memorizing science ideas or "facts" about matter properties, but instead are working with peers to figure out their own understanding of--and even design their own solutions for--real problems that occur in our natural world. When the phenomena being explored are relevant and accessible, multilingual students are better able to contribute and build from their previous understandings about the phenomena (González-Howard, Andersen, & Méndez Pérez, 2021).

Furthermore, engaging in phenomena-driven science instruction simultaneously supports multilingual students' science learning and language development (Lee & Stephens, 2020). Specifically, this is because the three-dimensional learning goals guiding students' exploration of the focal phenomenon explicitly integrate language and literacy in ways that are meaningful for students' sensemaking work. The various pedagogical approaches embedded in the OpenSciEd instructional model encourage multilingual students to draw upon, develop, and use multiple meaning-making resources, providing students with numerous opportunities to make their ideas public through both linguistic and multimodal forms of communication. As such, students are provided with ongoing opportunities to refine their language for scientific sensemaking (González-Howard et al., 2024).

OpenSciEd teacher materials also include educative features that are focused on multilingual students, such as callout boxes on the margins of the teacher guides. These educative features support teachers in considering whether particular learning moments might be spaces where they can leverage their multilingual students' language-related assets and/or address potential challenges the students might encounter. These educative features also help teachers provide additional in-time support and they explain why these instructional moves are important for multilingual students. They also range greatly, from suggesting particular ways to group students to unpacking the meaning of certain words in the context of students' scientific sensemaking work.

Collaborating with colleagues to address multilingual students' English development

As previously noted, OpenSciEd Elementary materials support all students in meaningfully developing and using a wide variety of communicative resources for making meaning and communicating scientific ideas, resources that include (but are not limited to) English. When considering multilingual students specifically, we encourage teachers to collaborate with colleagues, such as ESL specialists, to make necessary accommodations or modifications to ensure that all students have equal opportunities to authentically figure out scientific phenomena alongside their peers. Importantly, any accommodations or modifications should not lessen or take away from the rich sensemaking work that students are doing in the classroom.

Teacher Strategies for Successful Implementation

How can I fit all this science time into my schedule?

Since elementary school schedules and contexts vary greatly, OpenSciEd Elementary lessons are designed to be distributed across days in a flexible way. Recall that in OpenSciEd Elementary, a lesson does not equal one class period, but rather is a set of instructional time focused on answering a lesson question or figuring out something about a phenomenon.

OpenSciEd lessons typically last 60 minutes in grades K-2 and 90 minutes in grades 3-5, with some exceptions (noted in the teacher guides). It is up to the teacher to decide how to "chunk" that time into their unique schedules, and lessons are structured using components to support this distribution of science instructional time throughout school days and weeks.

- Each unit in grades K-2 includes 10 lessons. In order to complete a K-2 unit in about 8 weeks, a classroom needs to spend about 75 minutes per week doing science.
- Units in grades 3-5 include 12-15 lessons. In order to complete a grades 3-5 unit in about 8 weeks, a classroom needs to spend 135-170 minutes per week doing science.

Each unit's overview includes a section that answers the question, "How might I spread the components of this unit's lessons across instructional days?". This section includes an example schedule for how the unit's lesson components might be distributed over several weeks. Each unit also includes guidance for how the unit could be extended or condensed, if needed. Appendix A in this handbook provides blank templates for teachers to use to plan how a unit's lesson components can fit into their schedule.

When are the best times to "double dip" for more science time?

OpenSciEd Elementary teachers have reported using the following times of their day to teach various lesson components.

- Parts of a literacy block or specified read aloud time are useful for enacting Connect components that involve interacting with texts, such as an interactive read aloud of a book or article or partner reading of an infographic or article.
- Class circle time, such as a morning meeting or closing circle, are useful for Synthesize discussions and Navigate components.
- Occasionally, math time can be used to carry out data analysis or other science work in an Explore connected to math standards. (See each unit's matrix for details about which math standards are supported in which lessons.)

Why does it take so long the first time I teach a unit? How can we be more efficient with our class time?

OpenSciEd units may be quite different from the way teachers and students are used to doing science and take some getting used to. Having students do the heavy lifting of figuring things out for themselves takes time, but as students and teachers become more familiar with the routines and practices of this work, the pace quickens. Here are some tips to keep in mind about pacing:

- As with any new curriculum, teachers can expect to spend more time going through a unit the first time, and subsequent enactments of that unit will take less time because teachers know better what to expect.
- As students in your class and school engage in multiple OpenSciEd units, they will become more comfortable with asking questions, planning investigations, discussing what they figure out, etc., and lessons will move more quickly.
- One place lessons can seem to drag on is during discussions.
    - Review the ideas in the section headed "How can teachers facilitate more equitable discussions?" in this handbook.
    - Recall that prompts provided in OpenSciEd teacher guides are suggestions and need not all be asked. Use the look- and listen-for guidance and, when the class has agreed on the key points, move on.
- Establish setup and cleanup systems that work for your classroom context. Teachers often find it works well to prepare bins of materials for each group for easy distribution and collection of supplies.
    - Lessons that involve setup of materials include guidance for how to save and store materials for future use; in many cases, setup will be faster next time.

Why are there so many charts and how do I manage them?

The OpenSciEd instructional model relies on students' questions and ideas being made public. Students are invested and engaged in the work of their science class because they understand how it relates directly to making sense of phenomena they wonder about. Keeping visible the classroom records of students' ideas and progress gives them constant feedback about what has been accomplished through their work. These records take the form of Driving Question Boards, Notice and Wonder charts, collections of ideas for investigation, lists of related phenomena, Word Walls, Our/My Growing Ideas charts, Class Consensus Models, and more, so the class can continue to refer back to their ideas and see how they are changing as they figure things out.

OpenSciEd Elementary teachers have used the following strategies to manage these public records in their various classroom contexts:

- Use the teacher references provided in each unit to plan space in your classroom; use limited wall space strategically (such as for a consensus model the class will add to several times).
- Unit materials provide guidance about which charts are important to keep for reference and which ones might be useful only in a certain lesson; if a chart is not needed for future reference, consider creating it on a whiteboard instead of on paper.
- Using an easel or rack to clip chart papers together conserves space and provides access to charts as needed; the class can flip back and forth to the chart that is most relevant to them in a given discussion.
- Create a slide deck or running document as a digital public record and display the relevant sections as needed during a lesson.

How do I post lesson objectives without giving away what kids will figure out?

In the Navigate component that happens in each lesson of the OpenSciEd Elementary instructional model, the class works together to decide the next steps needed to figure out their questions. Therefore, students should have a clear idea of their goals for a given science period. However, many teachers are also required to post learning objectives for their classes, and defining at the beginning of a lesson what students will be figuring out would undermine the important work students will do themselves. To solve this problem, teachers can co-construct and post a lesson objective with students during the Navigate that follows the pattern of, "We are trying to figure out _____(the answer to this specific question or how to solve this engineering problem______". Consider highlighting any or all of the three dimensions in an objective you post, including the science and engineering practice that students will be using (such as modeling or planning an investigation), a crosscutting concept that students have been working with (such as cause and effect or systems), and/or a general mention of a disciplinary core idea (e.g., figuring out why surfaces feel hot or less hot). More information about 3D learning objectives can be found in STEM Teaching Tool #46.

Appendix A: Planning Tools

Sample 3-5 Unit Plan: Calendar Version

Unit Name: 3.1 Balanced Art (Field Test Version) **Number of Lessons:** 14

1	**Day 1**	**Day 2**	**Day 3**	**Day 4**	**Day 5**
	Lesson 1: Explore - Make observations and build initial sculptures (45 min) *More science time today for building!*	Lesson 1: Connect & Synthesize: Share experiences, related phenomena, and initial ideas for how they work (40 min)	Lesson 1: Synthesize - Build the Driving Question Board and then Brainstorm Ideas for Investigation (35 min)	Lesson 2: Navigate and define the purpose (20 min)	No science today.
2	**Day 6**	**Day 7**	**Day 8**	**Day 9**	**Day 10**
	Lesson 2: Plan and build a symmetrical design (25 min)	Lesson 2: Connect (Read Symmetry) & Synthesize Develop our model, Our Growing Ideas and Navigate (45 min) *Read book in circle time.*	Lesson 3: Navigate and Explore: Revisit previous designs and make observations (30 min)	Lesson 3: Explore - Build a design (25 min)	Lesson 3: Connect - Read part of Meet the Artists; then Synthesize by adding model ideas; brainstorm new sculpture design (35 min)
3	**Day 11**	**Day 12**	**Day 13**	**Day 14**	**Day 15**
	Lesson 4: Navigate - Brainstorm off-centered designs & Connect - Read Scientists Use Procedures (30 min)	Lesson 4: Explore: Distance, Weight and Artists tests (40 min)	Lesson 4: Synthesize - Add new ideas & Navigate (20 min)	Lesson 5: Navigate, Connect & Explore: Revisit previous ideas and text, and then plan our hanging designs (30 min)	Lesson 5: Explore - Build hanging designs (30 min)
4	**Day 16**	**Day 17**	**Day 18**	**Day 19**	**Day 20**
	Lesson 5: Synthesize - Add new ideas; individually model upward/downward forces; Navigate (30 min)	Lesson 6: Navigate- Revisit Category B sculptures; Explore: Plan a Category B Sculpture (30 min)	Lesson 6: Explore - Build a Category B Sculpture (25 min)	Lesson 6: Synthesize- Update our ideas; Connect- Brainstorm related phenomena; navigate (35 min)	No science today.

5	**Day 21**	**Day 22**	**Day 23**	**Day 24**	**Day 25**
	Lesson 7: Navigate and then Connect with video; Explore - Draw a model of moving sculptures (25 min)	Lesson 7: Explore - Build moving sculptures (25 min)	Lesson 7: Synthesize - discuss and update our ideas; Navigate (40 min)	Lesson 8: Navigate- Take Stock; Synthesize - Revisit our Growing Ideas; Start planning Art Exhibit (35 min)	Lesson 8: Planning and Building Sculptures (30 min)
6	**Day 26**	**Day 27**	**Day 28**	**Day 29**	**Day 30**
	Lesson 8: Extra day to touch up and finish sculptures (30 min)	Art Exhibit Showcase - Invite other staff and classes to visit the exhibit!	Lesson 9: Navigate and Explore a new type of sculpture; Connect- think about related objects that use magnets (35 min)	Lesson 9: Synthesize - Create a new model (30 min)	Lesson 9: Add to DQB and Navigate (25 min)
7	**Day 31**	**Day 32**	**Day 33**	**Day 34**	**Day 35**
	Lesson 10: Navigate and Explore - Do part of Develop Testable Questions (30 min)	Lesson 10: Explore - Finish developing and testing questions about magnets (25 min)	Lesson 10: Synthesize- Update our Growing Ideas; Connect- Read about a final artist; Navigate (35 min)	Lesson 11: Navigate & then Explore- Plan Investigation (25 min)	Lesson 11: Explore - Carry out investigation (30 min)
8	**Day 36**	**Day 37**	**Day 38**	**Day 39**	**Day 40**
	Lesson 11: Synthesize - discuss and add ideas to model; Connect - begin Magnets book; Navigate (35 min)	Lesson 12: Navigate - take stock of questions and then test magnets with different objects (30 min)	Lesson 12: Explore - Test new ideas - create hovering paperclip (25 min)	Lesson 12: Electric forces activity (30 min)	Lesson 12: Update ideas; read Magnets book (35 min)
9	**Day 41**	**Day 42**	**Day 43**	**Day 44**	**Day 45**
	Lesson 13: Navigate and Synthesize by taking stock of ideas (25 min)	Lesson 13: Explore - Build magnetic sculptures (40 min)	Lesson 13: Connect - Communicate and share sculptures (25 min)	Lesson 14: Navigate; Connect to a new context - adaptive clothing; Synthesize - revisit our Growing Ideas; start task (45 min)	Lesson 14: Finish designs and take stock of all our learning and celebrate! (45 min)

Sample K-2 Unit Plan: Calendar Version

Unit Name: K.1 Schoolyard Engineering **Number of Lessons:** 10

1	**Day 1**	**Day 2**	**Day 3**	**Day 4**	**Day 5**
	Science: L1 Explore (30)	**Circle time**: Classroom Agreements (20)	**Science**: L1 Synthesize (25) + Navigate (5)	**Read-aloud**: L2 Navigate (5) + Connect (10)	**Science**: L2 Explore (35)
2	**Day 6**	**Day 7**	**Day 8**	**Day 9**	**Day 10**
		Circle time: L2 Synthesize (5) + Navigate (5)	**Science**: L3 Navigate (5) + Explore (30)	**Read-aloud**: L3 Connect (15) **Circle time**: L3 Synthesize (5) + Navigate (5)	**Science**: L4 Navigate (5) + Explore (30)
3	**Day 11**	**Day 12**	**Day 13**	**Day 14**	**Day 15**
	Science: L4 Connect (10) + Synthesize (5) + L5 Navigate (5) + Connect (10)		**Science**: L5 Explore (20)	**Circle time**: L5 Synthesize (20) + Navigate (5)	**Science**: L6 Navigate (5) + Connect (10)
4	**Day 16**	**Day 17**	**Day 18**	**Day 19**	**Day 20**
	Science: begin L6 Explore (20)		**Science**: finish L6 Explore (5) + Synthesize (5) + Navigate (5)	**Read-aloud**: L7 Navigate (5) + Connect (15)	
5	**Day 21**	**Day 22**	**Day 23**	**Day 24**	**Day 25**
	Science: L7 Explore (20)	**Circle time**: L7 Synthesize (15) + Navigate (5)	**Science**: L8 Navigate (10) + Connect (10)		**Science**: L8 Explore (30)
6	**Day 26**	**Day 27**	**Day 28**	**Day 29**	**Day 30**
	Science: L8 Synthesize (5) + L9 Navigate (5) + Connect (10)		**Science**: begin L9 Explore (20)		**Science**: finish L9 Explore (15) + Synthesize (5) + Navigate (5)
7	**Day 31**	**Day 32**	**Day 33**	**Day 34**	**Day 35**
	Science: L10 Navigate (10) + Explore (10)		**Science**: L10 Synthesize (25)		**Science**: L10 Connect (5) + Navigate (10)

Blank Unit Planning Tool: Calendar Version

Unit Name: ________________________________ **Number of Lessons:** ____________________

Week 1	**Day 1**	**Day 2**	**Day 3**	**Day 4**	**Day 5**	**Notes**
Week 2	**Day 6**	**Day 7**	**Day 8**	**Day 9**	**Day 10**	
Week 3	**Day 11**	**Day 12**	**Day 13**	**Day 14**	**Day 15**	

	Day 16	Day 17	Day 18	Day 19	Day 20	Notes
Week 4						
	Day 21	Day 22	Day 23	Day 24	Day 25	
Week 5						
	Day 26	Day 27	Day 28	Day 29	Day 30	
Week 6						

Week 7	**Day 31**	**Day 32**	**Day 33**	**Day 34**	**Day 35**	**Notes**
Week 8	**Day 36**	**Day 37**	**Day 38**	**Day 39**	**Day 40**	
Week 9	**Day 41**	**Day 42**	**Day 43**	**Day 44**	**Day 45**	

Blank Unit Planning Tool: Weekly Version

Unit Name: ______________________________ **Number of Lessons:** ____________________

Instructional Week	Lesson Number(s)	What parts of the lesson will be taught in science time?	Will any parts of the lesson be taught outside of science time?	Note an important date/school function	Notes
1 ________					
2 ________					
3 ________					
4					

Instructional Week	Lesson Number(s)	What parts of the lesson will be taught in science time?	Will any parts of the lesson be taught outside of science time?	Note an important date/school function	Notes
________					
5 ________					
6 ________					
7 ________					

Instructional Week	Lesson Number(s)	What parts of the lesson will be taught in science time?	Will any parts of the lesson be taught outside of science time?	Note an important date/school function	Notes
8 ________					
9 ________					

Appendix B: Discussion Supports

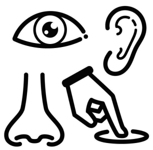
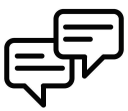
Prompts for Teachers and Students

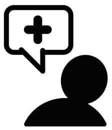
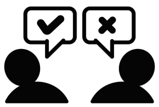
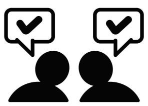
Initial Ideas Discussion	Building Understandings Discussion	Consensus Discussion
I noticed that _____.	Based on __(our investigation), it seems that _____.	I think _____ because _____.
I wonder _____.	I think _____ and my evidence is _____.	I agree with that idea because _____.
From my experience _____.	I/We figured out _____ because _____.	I disagree with that idea because _____.
I can connect with what you said because _____.	In our group we observed _____. What did other groups observe?	Your idea makes sense to me because _____.
If I understand you correctly, you are saying _____.	I would like to add on _____.	I would like to add on _____.
Can you say more about that?	We observed something different: _____.	I am not sure yet about _____. Can you help me (or us) understand?
What do you mean by _____?	We observed something similar: _____.	But what about _____?
	We are (still) wondering about _____.	I think you are saying _____. Am I right or can you clarify?
	What is your evidence?	It seems like we all agree that _____.
	I think you are saying _____. Am I right or can you clarify?	We all seem to be saying _____.
	We all seem to be saying _____.	

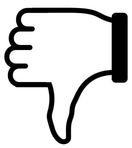
Discussion Prompts by Discussion Type

Initial Ideas Discussion	Building Understandings Discussion	Consensus Discussion
When eliciting initial ideas: • What are your ideas to explain/solve _____? • Why/how do you think _____ happens? • How might we solve _____ problem? • Have you ever experienced something like this? How was that like this? • What did you notice about _____? • What questions do you have? **When clarifying and encouraging student interaction and pressing for reasoning:** • Can you share what you mean by "_____"/(gesture)? • Can you tell us more about why you think that? • Who has a similar/different way of thinking about this topic? **When asking for or providing a synthesis of initial ideas:** • Who can summarize some of the initial ideas we've heard today? • So I'm hearing _____ and _____. Does that capture what we are currently thinking? Is there something I missed? • What new questions do we have? **When asking students how to investigate their initial ideas:** • What are some ways we could test our thinking? • What do we need to know to figure this out? • What could we do in our class to find answers to our questions?	**Setting and maintaining focus:** • Could someone tell us our question/problem we are trying to answer/solve? • We have a new piece of evidence. What does that mean for us? **When inviting a group to share:** • What are some of your ideas? • What are some important parts of your model? • Does this design do what we need it to do? How do we know? **When pushing for elaboration of evidence and reasoning:** • What evidence backs up what you are saying? • How does that idea fit with _____'s claim? • Can you tell us more about _____ part of your model/solution? Why did you draw/say/do that? Are you saying _____(restate the idea)? **When encouraging critique and student-to-student interaction:** • What questions do you have for your friends? • Does your evidence support your friends' ideas? If not, why? • Is there anything you would add? **To find tentative conclusions & next steps:** • What do we seem to agree upon? • What new questions do we have? • What else do we need to find out? What might we do next?	**During stock-taking:** • Could someone tell us the question/problem we are trying to answer/solve? • What are we thinking about our phenomenon? • What evidence supports our ideas? **When soliciting ideas to develop or modify the model or explanation:** • How should we represent it? Are we OK with that? • Do we agree? Do we need more evidence? • How are these explanations similar? How are they different? • How might we change our model or explanation to include those ideas? • What changes would you make to what you said/gestured? **When inviting support or critique:** • Are we missing anyone's ideas? • I'm hearing two different ideas: (restate ideas). What do we think about those? • Are there still places where we disagree? Can we clarify these? • Does it always work that way? **When soliciting ideas for next questions or investigations to pursue:** • What should we do next to figure out more about our questions? • What new questions do we have that might help us move forward?

Prompts with Icons

★	
	I noticed that __________.
	I wonder __________.
	I can connect with what you said because __________.
	Can you say more about __________?
	What do you mean by __________?

	♥
	I think __________ and my evidence is __________.
	I would like to add on to what __________ said.
	We observed something different: __________.
	We observed something similar: __________.
	We are still wondering about __________.
	We all seem to be saying __________.

▲	
	I think __________ because __________.
	I agree with that idea because __________.
	I disagree with that idea because __________.
	I'm not sure yet about __________ because __________.

Appendix C: Math Resources

Metric Unit Conversions

Length	Weight	Volume
10 millimeters (mm) = 1 centimeter (cm)	1,000 grams (g) = 1 kilogram (kg)	1,000 milliliters (mL) = 1 liter (L)
100 centimeters (cm) = 1 meter (m)		1,000 liters (L) = 1 kiloliter (kL)
1,000 meters (m) = 1 kilometer (km)		

Customary Unit Conversions

Length	Weight	Volume
1 foot (ft) = 12 inches (in)	1 pound (lb) = 16 ounces (oz)	1 cup (c) = 8 fluid ounces (fl oz)
1 yard (yd) = 36 inches (in)	1 ton = 2,000 pounds (lb)	1 pint (pt) = 2 cups
1 yard (yd) = 3 feet (ft)		1 quart (qt) = 2 pints (pi)
1 mile (mi) = 5,280 feet (ft)		1 gallon (gal) = 4 quarts (qt)

Time
1 minute (min) = 60 seconds (sec)
1 hour (h) = 60 minutes (min)
1 hour (h) = 360 seconds (sec)

Place Value Chart to the Billions=

Billions	Hundred Millions	Ten Millions	Millions	Hundred Thousands	Ten Thousands	Thousands	Hundreds	Tens	Ones
$1,000,000,000$	$100,000,000$	$10,000,000$	$1,000,000$	$100,000$	$10,000$	$1,000$	100	10	1

Decimal Place Value Chart

Thousands	Hundreds	Tens	Ones	Decimal Point	Tenths	Hundredths	Thousandths
1,000	100	10	1	.	0.1	0.01	0.001
				.			

Fraction Place Value Chart

Millions	Hundred Thousands	Ten Thousands	Thousands	Hundreds	Tens	Ones	Decimal Point	Tenths	Hundredths	Thousandths	Ten Thousandths	Hundred Thousandths	Millionths
$1,000,000$	$100,000$	$10,000$	$1,000$	100	10	1		$\frac{1}{10}$	$\frac{1}{100}$	$\frac{1}{1,000}$	$\frac{1}{10,000}$	$\frac{1}{100,000}$	$\frac{1}{1,000,000}$
							.						

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