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# NM STEM Ready! Science Standards Implementation Guide

## Overview

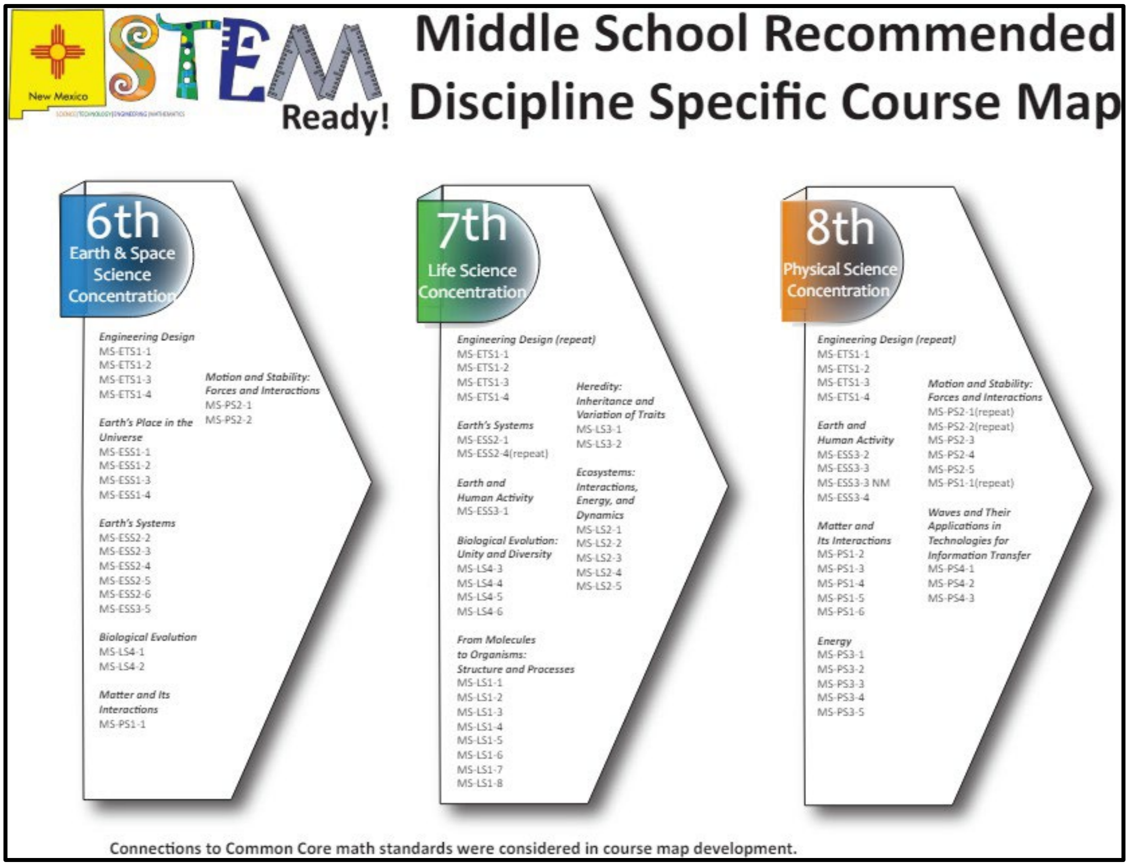
*A Framework for K–12 Science Education* marks a leap forward in how we think about science education and captures the advancements made in understanding how students best learn science that have been made over the last 30 years. The New Mexico Public Education Department (PED) and New Mexico public school teachers worked together over the course of spring 2024 to construct an updated Instructional Scope 2.0 document for the New Mexico STEM Ready! Science Standards.

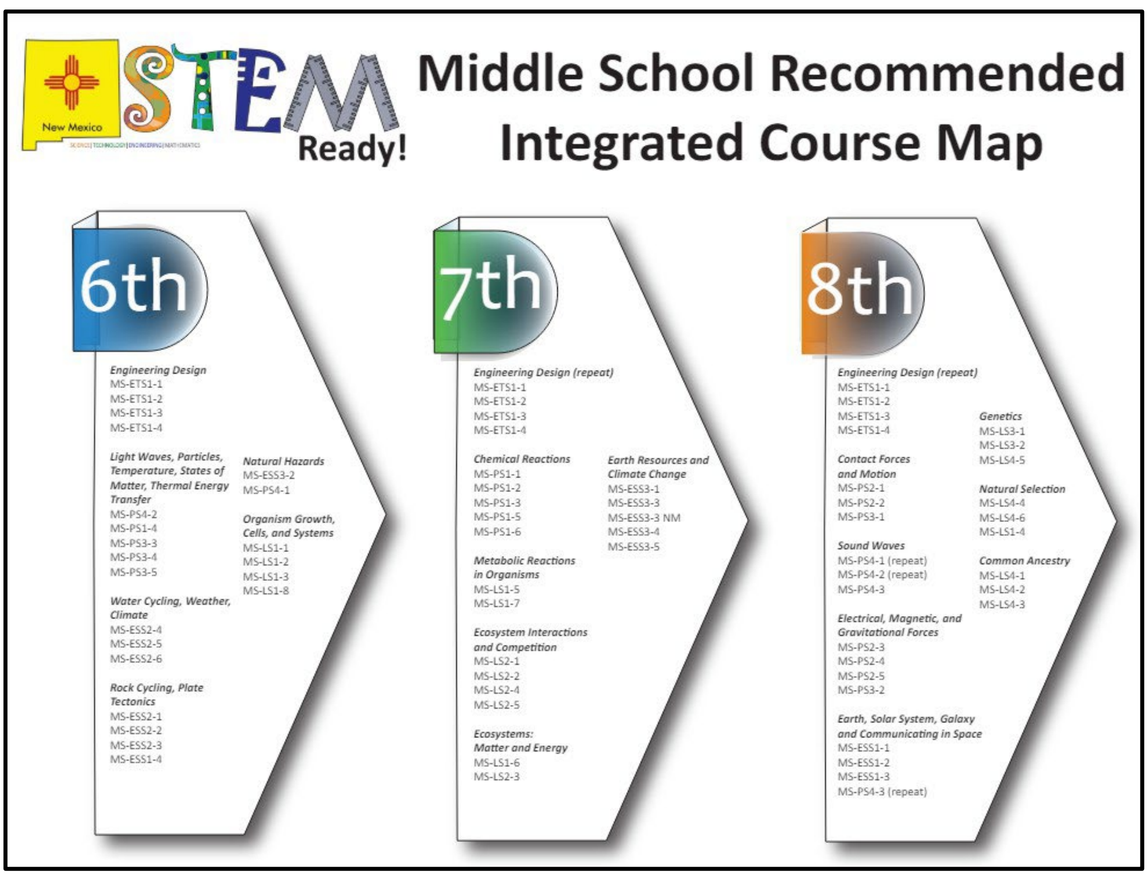
There are many public schools where high-quality instructional materials (HQIM) are present, and these should be used in the teaching of science. The updated 2.0 Instructional Scope includes some reference to the high-quality instructional materials (HQIM) used in the state, but also has updated sections that may be beneficial if they are not included with HQIM, like New Mexico relevant science phenomena and New Mexico's Multi-Layered Systems of Support (MLSS) section. It is recommended that schools with adopted HQIM continue to use their materials, but also reference the updated 2.0 Instructional Scope for context to better support New Mexico students.

New Mexico science teachers worked collaboratively to identify and construct an updated template, common misconceptions, sample phenomena, classroom assessment items, culturally and linguistically responsive (CLR) instructional strategies, Universal Design for Learning (UDL) strategies, MLSS, and cross-curricular connections for each performance expectation in the New Mexico STEM Ready! Science Standards.

The best practice of bundling related standards together to capture multiple aspects of a single phenomenon was not done, as local educational agencies (LEAs) should determine how best to bundle New Mexico STEM Ready! Science Standards based on their needs.

The standards are separated into their different disciplines and provided in a sequential format (EX: MS-PS1-1, MS-PS2-3, MS-ETS1-1), however, these standards are not meant to be taught individually on their own but bundled with other standards. Bundles are groups of standards arranged together to create endpoints for instruction and helps students see connections between concepts and allow more efficient use of instructional time. Work with your local school, or district, on creating bundles for your science courses or you can utilize resources and guidance from PED, such as the recommended discipline specific or integrated course maps (see images below).


New Mexico
STEM Ready!
Middle School Recommended Discipline Specific Course Map
6th
Earth & Space Science Concentration
Engineering Design
MS-ETS1-1
MS-ETS1-2
MS-ETS1-3
MS-ETS1-4
Earth's Place in the Universe
MS-ESS1-1
MS-ESS1-2
MS-ESS1-3
MS-ESS1-4
Earth's Systems
MS-ESS2-2
MS-ESS2-3
MS-ESS2-4
MS-ESS2-5
MS-ESS2-6
MS-ESS3-5
Biological Evolution
MS-LS4-1
MS-LS4-2
Matter and Its Interactions
MS-PS1-1
Motion and Stability: Forces and Interactions
MS-PS2-1
MS-PS2-2
7th
Life Science Concentration
Engineering Design (repeat)
MS-ETS1-1
MS-ETS1-2
MS-ETS1-3
MS-ETS1-4
Earth's Systems
MS-ESS2-1
MS-ESS2-4(repeat)
Earth and Human Activity
MS-ESS3-1
Biological Evolution: Unity and Diversity
MS-LS4-3
MS-LS4-4
MS-LS4-5
MS-LS4-6
From Molecules to Organisms: Structure and Processes
MS-LS1-1
MS-LS1-2
MS-LS1-3
MS-LS1-4
MS-LS1-5
MS-LS1-6
MS-LS1-7
MS-LS1-8
Heredity: Inheritance and Variation of Traits
MS-LS3-1
MS-LS3-2
Ecosystems: Interactions, Energy, and Dynamics
MS-LS2-1
MS-LS2-2
MS-LS2-3
MS-LS2-4
MS-LS2-5
8th
Physical Science Concentration
Engineering Design (repeat)
MS-ETS1-1
MS-ETS1-2
MS-ETS1-3
MS-ETS1-4
Earth and Human Activity
MS-ESS3-2
MS-ESS3-3
MS-ESS3-3 NM
MS-ESS3-4
Matter and Its Interactions
MS-PS1-2
MS-PS1-3
MS-PS1-4
MS-PS1-5
MS-PS1-6
Energy
MS-PS3-1
MS-PS3-2
MS-PS3-3
MS-PS3-4
MS-PS3-5
Motion and Stability: Forces and Interactions
MS-PS2-1(repeat)
MS-PS2-2(repeat)
MS-PS2-3
MS-PS2-4
MS-PS2-5
MS-PS1-1(repeat)
Waves and Their Applications in Technologies for Information Transfer
MS-PS4-1
MS-PS4-2
MS-PS4-3
Connections to Common Core math standards were considered in course map development.


New Mexico
STEM Ready!
Middle School Recommended Integrated Course Map
6th
Engineering Design
MS-ETS1-1
MS-ETS1-2
MS-ETS1-3
MS-ETS1-4
Light Waves, Particles, Temperature, States of Matter, Thermal Energy Transfer
MS-PS4-2
MS-PS1-4
MS-PS3-3
MS-PS3-4
MS-PS3-5
Water Cycling, Weather, Climate
MS-ESS2-4
MS-ESS2-5
MS-ESS2-6
Rock Cycling, Plate Tectonics
MS-ESS2-1
MS-ESS2-2
MS-ESS2-3
MS-ESS1-4
Natural Hazards
MS-ESS3-2
MS-PS4-1
Organism Growth, Cells, and Systems
MS-LS1-1
MS-LS1-2
MS-LS1-3
MS-LS1-8
7th
Engineering Design (repeat)
MS-ETS1-1
MS-ETS1-2
MS-ETS1-3
MS-ETS1-4
Chemical Reactions
MS-PS1-1
MS-PS1-2
MS-PS1-3
MS-PS1-5
MS-PS1-6
Metabolic Reactions in Organisms
MS-LS1-5
MS-LS1-7
Ecosystem Interactions and Competition
MS-LS2-1
MS-LS2-2
MS-LS2-4
MS-LS2-5
Ecosystems: Matter and Energy
MS-LS1-6
MS-LS2-3
Earth Resources and Climate Change
MS-ESS3-1
MS-ESS3-3
MS-ESS3-3 NM
MS-ESS3-4
MS-ESS3-5
8th
Engineering Design (repeat)
MS-ETS1-1
MS-ETS1-2
MS-ETS1-3
MS-ETS1-4
Contact Forces and Motion
MS-PS2-1
MS-PS2-2
MS-PS3-1
Sound Waves
MS-PS4-1 (repeat)
MS-PS4-2 (repeat)
MS-PS4-3
Electrical, Magnetic, and Gravitational Forces
MS-PS2-3
MS-PS2-4
MS-PS2-5
MS-PS3-2
Earth, Solar System, Galaxy and Communicating in Space
MS-ESS1-1
MS-ESS1-2
MS-ESS1-3
MS-PS4-3 (repeat)
Genetics
MS-LS3-1
MS-LS3-2
MS-LS4-5
Natural Selection
MS-LS4-4
MS-LS4-6
MS-LS1-4
Common Ancestry
MS-LS4-1
MS-LS4-2
MS-LS4-3

## The Standards

Each performance expectation (PE) begins with links to the *Next Generation Science Standards* and a snapshot of the performance expectation with the relevant Science and Engineering Practices (SEP), Disciplinary Core Ideas (DCI), and Cross Cutting Concepts (CCC). Also captured are the connections across the grade level or band (horizontal), connections across grade levels or bands (vertical), and connections to the *Common Core State Standards* (CCSS) in math and English language arts.

The Performance Expectation (PE) describes what a student is expected to be able to do at the completion of instruction. They are intended to guide the development of assessments, but they are not the assessment as such. They are not instructional strategies or instructional objectives, but they should influence and guide instruction. Most performance expectations contain a clarification statement and an assessment boundary statement to provide clarity to the performance expectation and guidance to the scope of the expectation, respectively.[1]

The foundation box, which is located below the PE, contains the learning goals that students should achieve and that will be assessed using the PED. The three parts to the foundation box are the science and engineering practices, the disciplinary core ideas, and the crosscutting concepts. The information contained in the foundation box is taken directly from *A Framework for K–12 Science Education*. Also included in the foundation box, where appropriate, are connections to engineering, technology, and applications of science as well as connections to the nature of science. These supplemental goals are related to the other material in the foundation box and are intended to guide instructions, but the outcomes are not included in the performance expectation.

The connections box identifies connections to other disciplinary core ideas at this grade level that are relevant to the standard, identifies the articulation of disciplinary core ideas across grade levels, and identifies connections to the CCSS in mathematics and in English language arts and literacy that align to this standard. The connections box helps support instruction and development of instructional materials.

[1] Pratt, Harold (2013) *The NSTA Reader's Guide to the Next Generation Science Standards*

## Common Misconceptions

What: This planning support identifies some of the common misconceptions students develop about a scientific topic.

Why: Our brains are highly advanced cause and effect reasoning machines. From birth, we begin to analyze effects to determine causes and provide some sort of reasoning for the whole event. The more events that support our reasoning, the stronger that learning becomes. So, every student in your classroom brings their own unique background knowledge into your classroom. Some of this is aligned to scientific understanding and some of this is misaligned to scientific understanding but aligned to that student's personal experiences. As science educators, we must always create space for students to bring their current understanding about a topic into our classroom so that we can begin to address understandings that are misaligned to scientific understanding. Some of these misunderstandings are not unique to a single student; rather, they are common to many students.

How: When planning with your HQIM look for ways to directly address with students some common misconceptions. The planning supports in this document provide some possible misconceptions and your HQIM might include additional ones. The goal is not to avoid misconceptions, they are a natural part of the learning process, but we want to support students in exploring the misconception and modifying incorrect or partial understandings.

## Sample Phenomena and New Mexico Relevant Phenomena

Located directly under the standards and misconceptions are the suggested sample phenomena. This section was constructed specifically for New Mexico with suggestions for phenomena that are relevant to New Mexico or relatable by New Mexico students..

What: Natural phenomena are observable events that occur in the universe and that we can use our science knowledge to explain or predict. The goal of building knowledge in science is to develop general ideas, based on evidence, that can explain and predict phenomena. Engineering involves designing solutions to problems that arise from phenomena and using explanations of phenomena to design solutions. In this way, phenomena are the context for the work of both the scientist and the engineer.

Why: Despite their centrality in science and engineering, phenomena have traditionally been a missing piece in science education. Anchoring learning in explaining phenomena supports student agency for wanting to build science and engineering knowledge. Students are able to identify an answer to "why do I need to learn this?" before they even know what "this" is. By centering science education on phenomena that students are motivated to explain, the focus of learning shifts from learning about a topic to figuring out why or how something happens. Explaining phenomena and designing solutions to problems allow students to build general science knowledge in the context of their application to understanding phenomena in the real world, leading to deeper and more transferable knowledge. Students who come to see how science ideas can help explain and model phenomena related to compelling real-world situations learn to appreciate the social relevance of science. They get interested in and identify with science as a way of understanding and improving real-world contexts.

Learning to explain phenomena and solve problems is the central reason students engage in the three dimensions of the *NGSS*. Students explain phenomena by developing and applying the DCI and CCC through use of the SEPs. Phenomena-centered classrooms also give students and teachers a context in which to monitor ongoing progress toward understanding all three dimensions. As students are working toward being able to explain phenomena, three-dimensional formative assessment becomes more easily embedded and coherent throughout instruction.

<u>How:</u> We use phenomena to drive instruction to help students engage in practices to develop the knowledge necessary to explain or predict the phenomena. Therefore, the focus is not just on the phenomenon itself. It is the phenomenon plus the student-generated questions about the phenomenon that guides the learning and teaching. The practice of asking questions or identifying problems becomes a critical part of trying to figure something out.

There could potentially be many different lines of inquiry about the same phenomenon. Teachers should help students identify different aspects of the same phenomenon as the focus of their questions. Students also might ask questions about a phenomenon that motivates a line of investigation that isn't grade appropriate or might not be effective at using or building important disciplinary ideas. Teacher guidance may be needed to help students reformulate questions so they can lead to grade appropriate investigations of important science ideas.

It is important that all students—including English Learners and students from cultural groups underrepresented in STEM—are supported in working with phenomena that are engaging and meaningful to them. Not all students will have the same background or relate to a particular phenomenon in the same way. Educators should consider student perspectives when choosing phenomena and should prepare to support student engagement in different ways. When starting with one phenomenon in your classroom, it is always a good idea to help students identify related phenomena from their lives and their communities to expand the phenomena under consideration.

Not all phenomena need to be used for the same amount of instructional time. Teachers could use an anchoring phenomenon as the overall focus for a unit, along with other investigative phenomena along the way as the focus of an instructional sequence or lesson. They may also highlight everyday phenomena that relate investigative or anchoring phenomena to personally experienced situations. A single phenomenon doesn't have to cover an entire unit, and different phenomena will take different amounts of time to figure out.

The most powerful phenomena are culturally or personally relevant or consequential to students. Such phenomena highlight how science ideas help us explain aspects of real-world contexts or design solutions to science-related problems that matter to students, their communities, and society. An appropriate phenomenon for instruction should help engage all students in working toward the learning goals of instruction as described by the DCIs, SEPs, and CCCs in the foundation box of the standard.

The process of developing an explanation for a phenomenon should advance students' understanding. If students already need to know the target knowledge before they can inquire about the phenomenon, then the phenomenon is not appropriate for initial instruction. Students should be able to make sense of anchoring or investigative phenomena, but not immediately, and not without investigating it using sequences of the science and engineering practices. Phenomena do not need to be flashy or unexpected. Students might not be intrigued by an everyday phenomenon right away because they believe they already know how or why it happens. With careful teacher facilitation, students can become dissatisfied with what they believe they already know and strive to understand it in the context of the DCI that the teacher is targeting.[2]

## Classroom Assessment Items

To align with the phenomena section above, this includes New Mexico based assessment items that directly relate, or comparatively, to the suggested New Mexico phenomena when available.

What: Classroom assessments (sometimes referred to as internal assessments) is used to refer to assessments designed or selected by teachers and given as an integral part of classroom instruction. This category of assessment may include teacher-student interactions in the classroom, observations of students, student products that result directly from ongoing instructional activities, quizzes tied to instructional activities, formal classroom exams that cover material from one or more instructional units, or assessments created by curriculum developers and embedded in instructional materials for teacher use.[3]

Classroom assessments can be designed to guide instruction (formative purposes) or to support decisions made beyond the classroom (summative purposes). Assessments used for formative purposes occur during the course of a unit of instruction and may involve both formal tests and informal activities conducted as part of a lesson. They may be used to identify students' strengths and weaknesses, assist students in guiding their own learning, and foster students' sense of autonomy and responsibility for their own learning. Assessments for summative purposes may be administered at the end of a unit of instruction. They are designed to provide evidence of achievement that can be used in decision making, such as assigning grades, making promotion or retention decisions, and classifying test takers according to defined performance categories. The results of all these assessments are evaluated by the teacher or sometimes by groups of teachers. These assessments play an integral role in students' learning experiences while also providing evidence of progress in that learning.

Why: In *Developing Assessments for the Next Generation Science Standards*, the National Research Council shared the following conclusions regarding assessing three-dimensional learning[4]:

- Measuring the three-dimensional science learning called for in the framework and the NGSS requires assessment tasks that examine students' performance of scientific and engineering practices in the context of crosscutting concepts and disciplinary core ideas. To adequately cover the three dimensions, assessment tasks will generally need to contain multiple

[2] Penuel, W. R., Bell, P., Neill, T., Morrison, D., & Tesoriero, G. (2018). *Selecting Anchoring Phenomena for Equitable 3D Teaching*. [OER Professional Development Session from the ACESSE Project] Retrieved from http://stemteachingtools.org/pd/sessione

[3] National Resource Council. (2014). *Developing Assessments for the Next Generation Science Standards.* Committee on Developing Assessments of Science Proficiency in K-12. Board on Testing and Assessments and Board on Science Education, J.W. Pellegrino, M.R. Wilson, J.A. Koenig, and A.S. Beatty, *Editors*. Division of Social Sciences and Education. Washington, DC: The National Academies Press.

[4] National Research Council. (2014). *Developing Assessments for the Next Generation Science Standards.* Committee on Developing Assessments of Science Proficiency in K-12. Board on Testing and Assessment and Board on Science Education. J.W. Pellegrino, M.R. Wilson, J.A. Koenig, and A.S. Beatty, *Editors*. Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

[5] STEM Teaching Tools (n.d.), http://stemteachingtools.org/tools accessed on July 7, 2021

components. It may be useful to focus on individual practices, core ideas, or crosscutting concepts in the various components of an assessment task, but, together, the components need to support inferences about students' three-dimensional science learning as described in a given performance expectation.

- The Next Generation Science Standards require that assessment tasks be designed so they can accurately locate students along a sequence of progressively more complex understandings of a core idea and successively more sophisticated applications of practices and crosscutting concepts.

- The NGSS places significant demands on science learning at every grade level. It will not be feasible to assess all the performance expectations for a given grade level with any one assessment. Students will need multiple – and varied – assessment opportunities to demonstrate their competence on the performance expectations for a given grade level.

- Effective evaluation of three-dimensional science learning requires more than a one-to-one mapping between the NGSS performance expectations and assessment tasks. More than one assessment task may be needed to adequately assess students' mastery of some performance expectations, and any given assessment task may assess aspects of more than one performance expectations. In addition, to assess both understanding of core knowledge and facility with a practice, assessments may need to probe students' use of a given practice in more than one disciplinary context. Assessment tasks that attempt to test practices in strict isolation from one another may not be meaningful as assessments of the three-dimensional science learning called for by the NGSS. (Developing assessments for NGSS, NRC, pp.44-46)

How: The amount of information that has been generated around designing and creating three-dimensional assessment tasks to meet the conclusions laid out above by the National Research Council has been overwhelming. The following free resources are available through STEM teaching tools to help you navigate this flood of information and translate it into your classroom. You should start by familiarizing yourself with the STEM Teaching Tools[5]: http://stemteachingtools.org/tools

- Practice Brief 18 on how teachers can develop formative assessments that fit a three-dimensional view of science learning.
- Practice Brief 26 on how to design formative assessments that engage students in three-dimensional learning.
- Practice Brief 30 on integrating science practices into assessment tasks
- Practice Brief 41 on integrating cross cutting concepts into assessment and instruction
- Practice Brief 33 on designing assessments for emerging bilingual students

## Culturally and Linguistically Responsive Instruction

What: Culturally and Linguistically Responsive Instruction (CLRI), or the practice of situational appropriateness, requires educators to contribute to a positive school climate by validating and affirming students' home languages and cultures. Validation is making the home culture and

[5] STEM Teaching Tools (n.d.), http://stemteachingtools.org/tools accessed on July 7, 2021

language legitimate, while affirmation is affirming or making clear that the home culture and language are positive assets. It is also the intentional effort to reverse negative stereotypes of non-dominant cultures and languages and must be intentional and purposeful, consistent and authentic, and proactive and reactive. Building and bridging is the extension of validation and affirmation. By building and bridging students learning to toggle between home culture and linguistic behaviors and expectations and the school culture and linguistic behaviors and expectations. The building component focuses on creating connections between the home culture and language and the expectations of school culture and language for success in school. The bridging component focuses on creating opportunities to practice situational appropriateness or utilizing appropriate cultural and linguistic behaviors. It is essential to recognize the impact of language in accessing the learning and guidance for linguistic vocabulary support are provided.

Why: Student understanding of science is shaped by their interactions with phenomena throughout their lives. Science educators must intentionally and purposefully legitimize the home culture and languages of students and validate their ways of knowing and understanding. In addition, create connections between the cultural and linguistic behaviors of the students' home culture and language and the culture and language of scientific understanding.

How: When planning instruction it is critical to consider ways to validate/affirm and build/bridge from your students' cultural and linguistic assets. There has been an overwhelming amount of guidance within STEM education about CLRI. The following STEM Teaching Tools can be a good place to start wrapping your mind around this topic[6].

- Practice Brief 15: Promoting equity in science education
- Practice Brief 47: Promoting equitable sensemaking
- Practice Brief 54: Building equitable learning communities
- Practice Brief 11: Indigenous ways of knowing and STEM
- Practice Brief 27: Engaging English language learners in science and engineering practices
- Practice Brief 71: Advancing equity and justice in science education
- Practice Brief 53: Avoiding pitfalls associated with CLRI

The planning supports for each performance expectation provide an example of how to support equity-based teaching practices. Look for additional ways within your HQIM to ensure all students are included in the pursuit of scientific understanding in your classroom.

## Multi Layered System of Supports (MLSS)

The Multi-Layered Systems of Support (MLSS) has been updated to include instructional, social-emotional, and behavioral supports for layers 1, 2, and 3. While not all supports can be listed to meet the needs of all students, general suggestions are provided for guidance. Work within your local control to best meet the needs of your students.

What: The Multi-Layered Systems of Support (MLSS) is designed to support teachers in planning instruction for the needs of all students. Each section identifies general supports (layer 1) for supporting pedagogically sound whole class science instruction, targeted supports (layer 2) for supporting those scholars that teachers identify as not understanding the topic, and students needing intensive support (layer 3) for those students needing longer duration or otherwise more

[6] STEM Teaching Tools (n.d.), http://stemteachingtools.org/tools accessed on July 7, 2021

intense support through small group instruction.

Why: MLSS is a holistic framework that guides educators, those closest to the student, to intervene quickly when students need additional support. The framework moves away from the "wait to fail" model and empowers teachers to use their professional judgement to make data-informed decisions regarding the students in their classroom to ensure academic success with grade level expectations of the New Mexico Science Standards.

How: When planning with your high-quality instructional materials (HQIM) use the suggested universal supports embedded in the sequence of instruction. If you do not have access to HQIM in your school, the universal (layer 1) support in this document can be used in planning your instruction.

## Cross-Curricular Connections

The very last section of the Instructional Scope is the cross-curricular connections. These include math and literacy standards that are supplied for the performance expectation of each standard, as well as career connections for relevant job connections.

What: In order to provide guidance on cross-curricular instruction, the standards are identified for common core English language arts (ELA) and mathematics. When reading the CCSS in mathematics and English language arts (ELA), consider the following questions:

- Should students have achieved these mathematics and ELA standards to engage in the learning of science, or could they be learned together?
- In what ways do the referenced mathematics and ELA standards help clarify the science performance expectations?
- Can any of the science core ideas be included as examples in the mathematics or ELA instruction?

Why: The cross-curricular connections utilizes common core ELA and mathematics standards identified in NGSS and provides suggestions for use within instruction so teachers are better able to see how these connections might live within their instruction.

How: When planning with your high-quality instructional materials (HQIM) use the suggested cross-curricular connections embedded in the sequence of instruction. If you do not have access to HQIM in your school, utilize the suggestions in this document that can be used in planning your instruction.

| STANDARDS BREAKDOWN | |
|---|---|
| Physical Science: Matter and its Interactions<br>MS-PS1-1<br>MS-PS1-2<br>MS-PS1-3<br>MS-PS1-4<br>MS-PS1-5<br>MS-PS1-6 | |
| **Grade** | **NGSS Discipline Overview** |
| **MS** | **Physical Science** |
| **Click to find the standards breakdown.** | **Teacher Background by Performance Expectation (PE)** |
| **PS1-1** | Students develop models of atomic composition of simple molecules and extended structures. The model should include individual atoms, molecules, extended structures with repeating subunits, and substances (solids, liquids, and gases at the macro level).<br><br>In the model, students describe relationships between individual atoms, combinations of atoms to form molecules, which can be made up of the same type or different types of atoms; some molecules can connect to each other. Students will need to identify the subatomic particles like the proton, neutron, and electron in their learning, but will not need to understand valence electrons or deeper concepts surrounding the electron cloud. In some molecules, the same atoms of different elements repeat, in other molecules, the same atom of a single element repeats. This can often be a point of confusion so multiple models of these types will be beneficial for students as they explain the differences.<br><br>Students will need to use models to describe pure substances that are made of the same individual atoms or molecules. Each pure substance is made up of one of the following: individual atoms of the same type that are connected to form extended structures, individual atoms of different types that repeat to form extended structures (e.g., sodium chloride), individual atoms that are not attracted to each other (e.g., helium), molecules of different types of atoms that are not attracted to each other (carbon dioxide), molecules of different types of atoms that are attracted to each other to form extended structures (sugar, nylon), and molecules of the same type of atom that are not attracted to each other (e.g., oxygen).<br><br>Students will need to understand chemical symbols as representations of these substances and how to differentiate between individual atoms of elements compared to molecules. Chemical formulas are a combination of numbers and letters (symbols), like $H_2O$ used to represent substances. The letters represent the symbol of an element from the Periodic Table, like H is for hydrogen. The small numbers in the chemical formula to the right of a symbol are called subscripts and used to show the number of atoms for the symbol it is paired with. In the example of $H_2O$, this formula tells us that there are two elements: hydrogen and oxygen in this formula and that there are specifically two atoms of hydrogen since the two are paired to the H. |

<table>
<tr><th colspan="5">Standards Breakdown</th></tr>
<tr><td>MS</td><td colspan="4"><u>Physical Science 1-1</u></td></tr>
<tr><td rowspan="4">PS1-1</td><td colspan="4">The performance expectation below was developed using the following elements from the NRC document, A Framework for K-12 Science Education.</td></tr>
<tr><td rowspan="2">MS-PS1-1: Develop models to describe the atomic components of simple molecules and extended structures.<br><br>Clarification Statement: Instruction should emphasize developing models of molecules that vary in complexity.<br><br>Assessment Boundary: Do NOT include valence electrons and bonding energy, discussing ionic nature of complex structures, or a complete description of all individual atoms in a complex molecule or extended structure is NOT required.</td><td>SEP</td><td>DCI</td><td>CCC</td></tr>
<tr><td>Developing and Using Models<br>Modeling in 6–8 builds on K–5 and progresses to developing, using and revising models to describe, test, and predict more abstract phenomena and design systems.<br>• Develop a model to predict and/or describe phenomena.</td><td>PS1.A: Structure and Properties of Matter<br>• Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms.<br>• Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals).</td><td>Scale, Proportion, and Quantity<br>• Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.</td></tr>
<tr><td colspan="4">These standards are not meant to be taught individually on their own, but bundled with other standards. Bundles are groups of standards arranged together to create endpoints for instruction and it helps students see connections between concepts and allow more efficient use of instructional time. Work with your local school, or district, on creating bundles for your middle school science courses or you can utilize resources and guidance from <u>NMPED</u>.</td></tr>
</table>

## Common Misconceptions

- Only one model of the atom is correct.
- The electrons in an atom orbit its nucleus, like planets in our solar system orbit the sun.
- Electron clouds are pictures of electrons in their orbits.
- Electrons and protons are the only fundamental particles.
- The electron cloud is like a rain cloud, with electrons inside of it like drops of water.
- The current model of the atom is the right model.
- Atoms can disappear after time.
- Atoms are microscopic versions of elements—hard or soft, liquid or gas, etc.
- Atoms can be seen with a microscope.
- Atoms move, so they are alive.
- An electron shell is hard, like an eggshell.
- Atoms "own" the electrons in their orbits.
- Pure substances cannot be broken down into other substances.
- Pure substances can always be visually identified by consistency among physical features alone.
- Hydrogen is a typical atom.
- Electrons are larger than protons.
- An electron cloud has electrons in it, but the cloud itself is made of some other material.
- Students struggle with understanding chemical formulas representing elements and molecules.

## New Mexico Relevant Phenomena

*When available, you should use your locally selected or created high quality instructional materials. However, the following is an example phenomenon you can use if you don't have local high quality instructional materials available.*

*How can we make something new that was not there before? What happens when a bath bomb is added to water (and what causes it to happen)?*

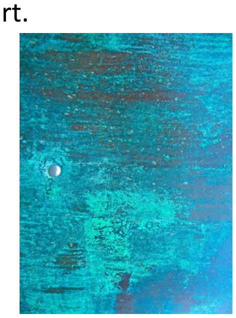
When solid bath bombs are added to water, they start breaking apart, and gas bubbles appear on and around them for a few minutes, until no solid is left. We observe different bath bombs and what they do when added to water and then develop individual models and explanations to show what is happening at a scale smaller than we can see.

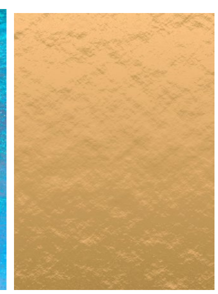
This is an opportunity for students to observe phenomena in action by allowing students to complete this hands-on inquiry. If resources are available, allow students to make their own DIY bath bomb and observe changes by varying the amounts of sodium bicarbonate, citric acid, and Epsom salt. Encourage students to observe and document the various reactions based on the variable (amount of sodium bicarbonate, etc) was added.

OpenSciEd 7.1: Chemical Reactions and Matter: [7.1 Chemical Reactions & Matter - Unit Download - OpenSciEd]

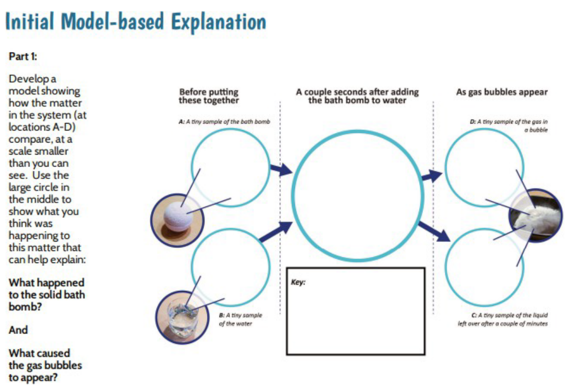
*How are things, like copper, changed in a way that cannot be undone? What are some different art methods that create something new?*

Through this phenomena, we'll explore unique changes to materials. These changes can often result in beautiful pieces that translate into art. If possible, showcase community, or locally relevant, art/jewelry pieces with different mediums or methods. Share with students that we will be using some different methods to create science art.





Have students compare the two images and complete some notices and wonders. Ask students if these two images are the same thing. Complete an investigation on simple copper patina within the classroom. As students observe the different changes to copper, explain that we will develop models to show what copper is before and after these changes using models of what is happening at the smaller scale we cannot see.

| **Classroom Assessment Items** | |
|---|---|
| *When available, you should use your locally selected or created high quality instructional materials. However, the following is an example assessment item you can use if you don't have local high quality instructional materials available.* | |
| Initial Model Based Explanation<br> | Copper Art<br>Sarah visited an art gallery on a recent trip to Albuquerque and the art museum (link to local artist showcased on Today Show if you want to find more specific images). She saw different works of metal art that all seemed to be made of the same metal copper, but had different colors and shapes. They learned about the various ways in which you can manipulate copper through patinating, a process by which chemicals are used purposefully to induce colors on the surface of metal. Then, in science class, they learned about compounds and different substances called copper salts that can cause this. Here is a list of the copper salts they used and learned about. |

Part 2:
Now use your model to explain:
a. What happened to the solid bath bomb?
b. What caused the gas bubbles to appear?

Sourced from Open Sci Ed Lesson 1 [7.1 Chemical Reactions & Matter - Unit Download - OpenSciEd]

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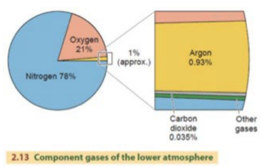
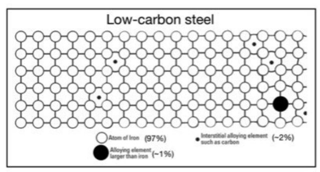
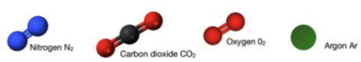
A quick internet search provides you with additional models that will help explain this phenomenon.




Draw an **atomic model** that explains the phenomenon of mass being added to burning steel wool. You may borrow ideas from David or the models above but your model must include both bulk and atomic scales. Make sure you identify and describe the components of your model.

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Water Structure

On a hot summer day you and your friends drink water. One of your friends asks, "I wonder what water looks like?"

A water molecule is made up of two hydrogen atoms and one oxygen atom.

| Copper Salts | |
|---|---|
| Copper oxide II (CuO) |  |
| Copper monosulfide (CuS) |  |
| Copper chloride |  |

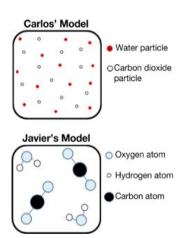
**Images used from [Tarnish, Part 1: The beginning]*

After doing an investigation, Sarah saw that one of the products had turned black, which is something they hadn't seen in the museum. Evaluate the chart to determine what they were observing.
-Identify which elements were being observed.
-Draw an **atomic model** that explains the phenomenon of copper being tarnished during the art process using copper and oxygen that resulted in Sarah's observations. Make sure you identify and describe the components of your model.

---

Carlos' and Javier's atomic model face off

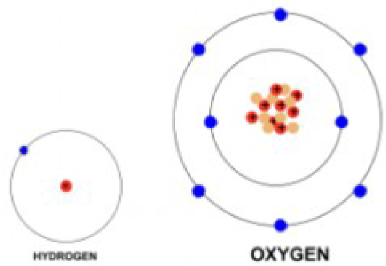
Evaluate two models to determine if one scale better shows that carbon dioxide and water are different substances.
-Whose model is drawn at a scale that better shows carbon dioxide and water to be different substances. Explain why you chose this model.
-Explain why you did not choose the other model and its scale.




The scale of a drawing refers to how much distance in

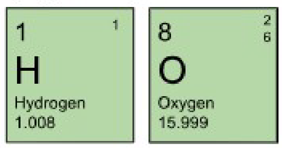
| | | |
|---|---|---|
| | | real life is represented by a certain distance in the |

Figure 1- Models of the Atoms




Hydrogen and Oxygen atom models as blue dots representing the electrons, red dots representing protons and orange dots representing the neutrons.

Figure 2: Hydrogen and Oxygen Atoms in the Periodic Table




Hydrogen and Oxygen Atoms In The Periodic Table
Hydrogen has atomic number 1, atomic mass number is 1.008.
Oxygen has atomic number 8 and atomic mass number is 15.999.

Your Task

In the questions that follow, you will develop and use a model to describe the scale and proportion of the atoms and molecules that make up water.

Question 1: Using Figures 1 and 2, complete the following table:

| Atom | Number of Protons | Number of Neutrons | Number of Electrons |
|---|---|---|---|
| Hydrogen | | | |
| Oxygen | | | |

Question 2: Using Figures 1 and 2 and the table in Question 1, explain the scale and proportion of these two atoms.

The ____________(oxygen/hydrogen) atom is larger because it has ____________(more/less) protons, neutrons, and electrons.

The ____________(oxygen/hydrogen) atom is smaller because it has ____________(more/less) protons, neutrons, and electrons.

Question 3: You ask your friends to draw a model that represents how hydrogen and oxygen atoms make up water molecules. They draw their models at different configurations as shown below.

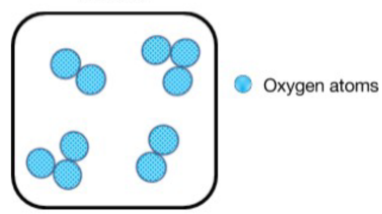
model. For instance, a map of the world and the map of your school are drawn at different scales.

Oxygen gas and ozone gas are both made of oxygen atoms. Two students were asked to draw a model of a mixture of oxygen gas and ozone gas showing why they are different substances. They drew their models at different scales, as shown to the lower right.

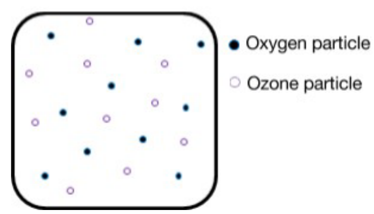
-Which model (A or B) is drawn at a scale that better shows why oxygen gas and ozone gas are different substances? Explain your choice.

-Explain why you did not choose the other model and its scale

Model A




Model B




Sourced from [Next Generation Science Assessment]

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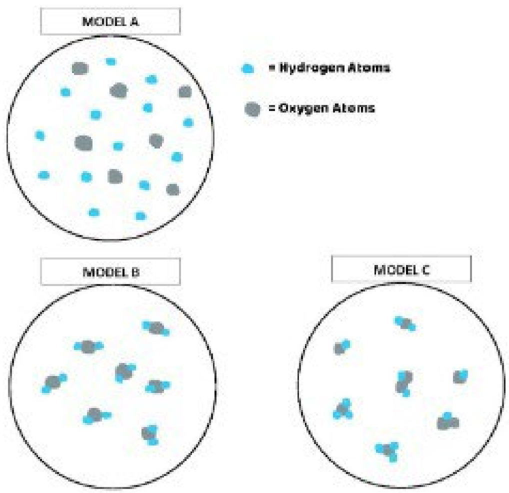
Anna vs. Carla

The scale of a drawing refers to how much distance in real life is represented by a certain distance in the drawing. For instance, a map of the world and the map of your school are drawn at different scales.

Anna and Carla were each asked to draw a model to show why water and bromine are different substances. They drew their models at different scales.

Question 1: Which model (Anna's or Carla's) is drawn at a scale that better shows why water and bromine are different substances? Explain your choice.



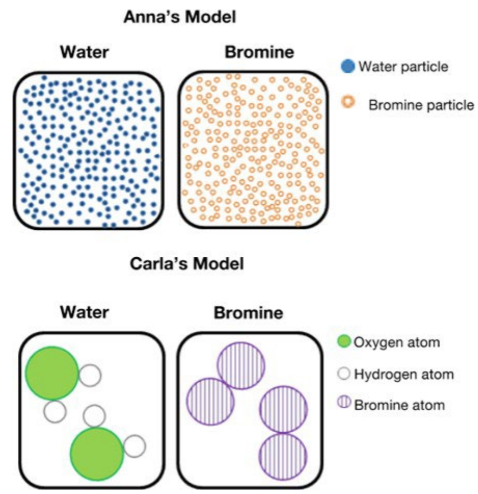

Which model is drawn at a configuration that best represents water molecules? Explain why you chose this model.

Question 4: Explain why you did not choose one of the other configurations and its scale.

Question 5: Based on what you have learned about atoms and molecules, draw a model of a water molecule to scale and proportion. Be sure to include the  protons, neutrons and electrons. Create a legend or label all the parts of your water molecule.

Sourced from SEEd Water Structure SEEd 8.1.1 Formative Assessment

Question 2: Explain why you did not choose the other model and its scale?




Sourced from Next Generation Science Assessment

**Culturally and Linguistically Responsive Instruction**

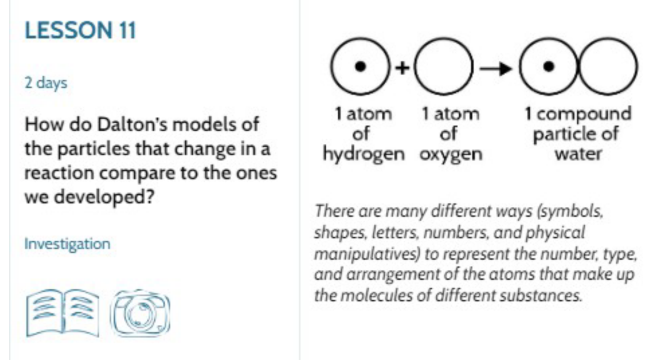
| *Validate and Affirm* | *Build and Bridge* | *Linguistic Vocabulary Support* |
|---|---|---|
| Where in your life have you experienced interactions with atoms or elements or molecules? What did these interactions mean to you? | Build a Driving Question Board (DQB) where students can add their questions and re-address their learning through time. Revisit the board often to help students make sense of their science learning – work towards a consensus model of these concepts throughout the unit. | Build a driving question board where students can stick questions and re-address their learning over time. Revisit this board often to help students make sense of their science learning. Bring those questions to group discussion.<br><br>Encourage students to work with vocabulary in meaningful ways. As students engage in sensemaking, students discuss complex ideas with everyday vocabulary and use many different verbal and non-verbal strategies to community their ideas. A |

| | | | |
|---|---|---|---|
| | | | common practice is to create an interactive "word wall" with students, with all the terms they have used when thinking and talking about the phenomena over the course of the unit. Overtime, teachers support, encourage, and/or require students to use proper terms as they ask questions, design experiments, and argue with evidence. Some vocabulary to utilize include: atom, atomic structure, extended structure, protons, electrons |
| | **Planning for Multi-Layer System of Support (MLSS) & Universal Design Learning** | | |
| | ***Layer 1***<br>***Core Instruction + Universal*** | ***Layer 2***<br>***Core + Targeted*** | ***Layer 3***<br>***Core + Targeted + Intensive*** |
| | *Instructional/Academic Supports* | | |
| | **Recruiting Interest:** Create different models of molecules (i.e., drawings, ball and stick, computer model) showing the relevant components and relationships, including individual atoms (elements), molecules (water and carbon dioxide), repeating subunits (crystals, polymers, plastics, carbohydrates) and substances (solid, liquid, and gasses at the macro level) to show that models can vary in complexity, and each can serve a different purpose.<br><br>**Sustaining Effort & Persistence:** Set a vision for the goal and why it matters through *Engagement* and student ownership in learning of phenomenon.<br><br>**Universal Design for Learning**<br>Representation<br>Engagement<br>Action and Expression<br>STEM Ready UDL Supports | **Executive Functions:** Guide appropriate goal-setting with small checkpoints for each lesson or student understanding.<br><br>Provide prepared manipulatives to show atoms and their interactions with each other. Be prepared to discuss how these models can represent different kinds of atoms and molecules. | Consider the misconceptions in content and skills needed within the PE and identify students for small group intervention.<br><br>EX: Provide an exemplar model of an atom with a pre-completed legend of the particles. Provide an exemplar model of other molecules and compounds.<br><br>Ask the student to share similarities and differences. Provide immediate correction and feedback to specific notices and wonders.<br><br>Provide opportunities to respond to the following in writing, then verbally:<br>1. What is the connection to atoms and the world?<br>2. Show me the particles that make up [atoms, molecules, Helium, etc).<br>3. Draw a model of a solid, like metal copper. |
| | *Social Emotional Supports* | | |

| | | |
|---|---|---|
| Integrate CASEL Playbook Strategies into your whole class routines or instruction. Some emphasized strategies/suggested activities are:<br><br>**Self/Social Awareness:** After introducing the phenomenon, utilize the Optimistic Closure-Human Bar Graph (p.39) for their current understanding of the phenomenon or questions. | Provide small-group support for students in need of focused skill instruction related to self-awareness, self-management, social awareness, relationship skills, and responsible decision making.<br><br>Increase positive reinforcement within the classroom for positive behavior. | Ensure that all learning environments allow students to thrive by considering the PBIS Sensory Tools.<br><br>Develop consistent Behavior Meetings to help build consistency and support for the students.<br><br>Additional student stakeholders may offer additional support through Counselor Referral or Collaboration with a student's physician or mental health provider. |

| *Behavioral Supports* | | |
|---|---|---|
| For all students, the use of Clear, consistent, and predictable consequences helps build a productive learning environment.<br><br>Ensure the use of a PBIS Behavior Contract during lab investigations and hands-on learning to ensure Layer 1 routines are supported. | Ensure the use of a PBIS Behavior Contract during lab investigations and hands-on learning to ensure Layer 1 routines are supported.<br><br>With challenging academic learning, utilize PBIS Structured Breaks throughout the learning cycle to support the multi-sensory environment of phenomena-based science. | Utilize the PBIS Check In Check Out (CIC O) to engage all student stakeholders in creating a consistent learning environment. |

| **Cross-Curricular Connections** | |
|---|---|
| *ELA/Literacy* | *Mathematics* |
| **RST.6-8.7:** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-PS1-1) | **MP.2**: Reason abstractly and quantitatively. (MS-PS1-1)<br><br>**MP.4:** Model with mathematics. (MS-PS1-1)<br><br>**6.RP.A.3:** Use ratio and rate reasoning to solve real-world and mathematical problems. (MS-PS1-1)<br><br>**8.EE.A.3:** Use numbers expressed in the form of a single digit times an integer power of 10 to estimate very large or very small quantities, and to express how many times as much one is than the other. (MS-PS1-1) |
| Create a model of an element, molecule, and a compound. | Provide the following graphic to facilitate a number talk, or notice/wonder, with students to make the conceptual understanding. |

| | | |
|---|---|---|
| | Create a key/legend or label the model.<br><br>Have students explain the similarities and differences between the atoms in the model.<br>**Have students try to make various representations or allow them to partner to see the different ways atomic structure can be shown.* |  |
| | *Career & Skill Connections* | |
| | Biology<br>Chemistry<br>Conservation science<br>Engineering | Farming<br>Mechanical engineering<br>Meteorology<br>Urban planning |

| Grade | NGSS Discipline Overview |
|---|---|
| MS | Physical Science |
| Click to find the standards breakdown. | **Teacher Background by Performance Expectation (PE)** |
| **PS1-2** | Building on their knowledge of atoms, students will explore how atomic arrangements influence a substance's properties. Each pure substance has unique physical (density, color, boiling point) and chemical properties (reactivity) that help identify it.<br><br>Physical properties are inherent characteristics of a substance that can be observed and measured without changing its atomic composition. They describe the substance itself, like its "fingerprint." Here are some key physical properties and their definitions:<br>● Density is the mass of a substance per unit volume. It essentially tells you how much "stuff" is packed into a certain space for that substance.<br>● Boiling Point is the temperature at which a substance changes from a liquid to a gas. EX: Water boils at 100°C (212°F), while liquid nitrogen boils at a much lower temperature of -196°C (-321°F).<br>By analyzing data (like density), students will distinguish between physical and chemical properties. Physical properties describe a substance itself, while chemical properties tell us how a substance reacts with others. Chemical reactions involve rearrangement of atoms, forming new substances with different properties than the originals.<br><br>To identify a chemical reaction, students will learn about five key signs: precipitation (solids forming), gas release, temperature changes, and color changes. Chemical formulas, introduced earlier, will help students understand reaction equations. These equations show reactants (starting materials) on the left and products (new substances) on the right, separated by an equal sign.<br><br>Students will organize data on physical and chemical properties in tables or charts to analyze patterns before and after a reaction. They will use the five signs to determine if a reaction occurred and analyze data to support their conclusions. Finally, students will model the atomic rearrangement during the reaction and explain, in writing, how changes in properties relate to this rearrangement. |

| Standards Breakdown | | | | |
|---|---|---|---|---|
| MS | Physical Science 1.2 | | | |
| **PS1-2** | *The performance expectation below was developed using the following elements from the NRC document, A Framework for K-12 Science Education* | | | |
| | **MS-PS1-2: Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.** | **SEP** | **DCI** | **CCC** |
| | **Clarification Statement:** Examples of reactions could include burning sugar or steel wool, fat reacting with sodium hydroxide, and mixing zinc with hydrogen chloride.<br><br>**Assessment Boundary:** Assessment is limited to analysis of the following properties: density, melting point, boiling point, solubility, flammability, and odor. | **Analyzing and Interpreting Data**<br>Analyzing data in 6–8 builds on K–5 and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.<br>• Analyze and interpret data to determine similarities and differences in findings.<br><br>**Scientific Knowledge is Based on Empirical Evidence**<br>• Science knowledge is based upon logical and conceptual connections between evidence and explanations. | **PS1.A: Structure and Properties of Matter**<br>• Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.<br>**PS1.B: Chemical Reactions**<br>• Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. | **Patterns**<br>• Macroscopic patterns are related to the nature of microscopic and atomic-level structure. |
| | *These standards are not meant to be taught individually on their own, but bundled with other standards. Bundles are groups of standards arranged together to create endpoints for instruction and it helps students see connections between concepts and allow more efficient use of instructional time. Work with your local school, or district, on creating bundles for your middle school science courses or you can utilize resources and guidance from NMPED.* | | | |
| | **Common Misconceptions** | | | |

- All physical changes are reversible/all chemical changes are irreversible.
- Changes of state are chemical changes.
- Chemical changes always occur when substances are mixed/dissolved.
- An increase or decrease in the temperature of a chemical system always indicates a
- When plants grow, it takes in atoms from the environment that become part of the plants.
- The mass of a silver coin is greater after it tarnishes because the number of silver atoms stayed the same and some sulfur atoms from the air linked to the silver atoms to form silver sulfide molecules.
- Matter is not created when living organisms grow. The matter added to
- Wood floats and metal sinks.
- All objects containing air float.
- Liquids of high viscosity are also liquids with high density.
- Adhesion is the same as cohesion
- A "thick" liquid has a higher density than water.
- Mass and volume, which both describe an "amount of matter," are the same property

| | | | |
|---|---|---|---|
| | chemical change.<br>● During a chemical reaction, atoms stay the same but rearrange to form new molecules.<br>● After a chemical reaction occurs, some of the atoms are connected to different atoms than they were in the starting molecules. (This item uses circles to represent atoms.) | their bodies comes from atoms that were outside the organism.<br>● Elements can form other elements.<br>● All solutions are pure liquids.<br>● Objects float in water because they are lighter than water.<br>● Objects sink in water because they are heavier than water.<br>● Mass/volume/weight/heaviness/size/density may be perceived as equivalent or the same. | ● Chemical changes perceived as additive, rather than interactive. After chemical change the original substances are perceived as remaining, even though they are altered.<br>● There is such a thing as an unbalanced chemical equation.<br>● The Law of Conservation of Mass does not apply to atoms. |

| **New Mexico Relevant Phenomena** | |
|---|---|
| *When available, you should use your locally selected or created high quality instructional materials. However, the following is an example phenomenon you can use if you don't have local high quality instructional materials available.* | |
| *What is the composition of a substance and can something new be made with those same building blocks?* | *Imagine that you are in an art gallery and see an exhibit of clay pots. How could you tell whether they had been fired in a kiln, or were raw, unheated clay? What would you look for?* |

Onions are one of the most common ingredients in all the kitchens of the world. This also results in one of the most common events for the cook, which is potential crying while cutting the onion. Onions gather sulfur from the ground while it is growing. It releases the sulfur when you cut or prepare it. When it reaches your eye, the sulfur acts as an irritant and your eyes secrete tears to counter the irritant. If possible, have onions available in the classroom for students to experience and generate a list of questions from the experience and share personal experiences of using onions. If you're not able to provide onions, consider finding various images of people using onions in the kitchen and asking students, what do you observe, what can you infer, and what can you predict would happen from the image. Here are a few suggested images below to use:

*Image from pixabay*

Incorporate native American culture into the lesson through the process of pottery making (especially when clay is being fired to turn it into ceramics). Make connections to local or community context as well as comparison to the suggested phenomenon.

Native Americans have a long tradition and history of pot making. They used pots for varied purposes. By modifying the proportion of water, clay and baking temperatures beautiful pottery is produced. Maria Poveka Martinez' pottery has been sought after by collectors worldwide because of its unique features and beauty. Some samples of Maria's pottery techniques can be observed through this video Pottery Techniques of Maria Martinez. Additionally, this can also be observed through an investigation with different types of clay and comparable materials.

*Imagine that you are hiking and find the two rocks in the photos below. How would you know whether they were chemically weathered or physically weathered? What signs would you look for?*

In New Mexico, the beautiful rocks that we see in our mountains and on our hikes undergo changes over time due to two main processes: physical and chemical weathering. If able, have students go outside and make physical observations about the rocks or landforms they see. Look for examples of physical and chemical weathering on surfaces around the school. If unable to observe outside, utilize some of the photos below to spark discussion with the students: what colors are they seeing, what rock shapes do they see, are the rocks breaking?

| | | |
|---|---|---|
| | <br>*Image from pixabay*<br><br>**Sourced from The Wonder of Science*<br>*(This can also be an opportunity based on your local community to see if there are onion fields in your community or even in small at home gardens for students. Be sure to provide opportunities for students to share this experience through discussion or other methods.)*<br><br>*How can we make something new that was not there before?*<br><br>Continued from 7.1 Chemical Reactions & Matter reintroduce, or use if not selected the first time, the phenomenon of observing what happens when a store bought bath bomb is added to water. Students make observations of the bath bomb multiple times: 1) before adding it to water by passing it around the class, 2) right after the bath bomb has been added to water, and 3) after the bath bomb has been in the water for 10 minutes. | Physical weathering might include cracks in the concrete due to expansion and contraction (hot and cold weather), wind abrasion to signs and paint, abrasion to steps due to foot traffic. Chemical weathering might include things like rust on metal surfaces, color change on bricks due to pollution.<br><br>Show students the photos of physical and chemical weathering of rocks and ask them to choose which are physically weathered and which are chemically weathered. Do they see color changes? Corners being softened by abrasion, jointing of rocks due to heat and cold?<br><br>The chemical and physical properties of this standard can be observed through physical and chemical weathering. Physical weathering happens when wind and water wear down the surface of rocks, creating patterns and smoothing edges. Physical and Chemical Weathering of Rocks. Chemical weathering occurs when minerals in the rocks react with water and air, slowly changing the rock's composition. Chemically weathered rocks often exhibit features like color banding at the edges and drastic changes in texture. The interesting formations in New Mexico caves like those in Carlsbad are due to chemical weathering and deposition. |

## Classroom Assessment Items

*When available, you should use your locally selected or created high quality instructional materials. However, the following is an example phenomenon you can use if you don't have local high quality instructional materials available*

Mixing Clear Liquids

Tori dissolved two solids (Solid A and Solid B) into separate beakers, forming two clear liquids. Then, she mixed those two clear liquids together. She found that a yellow solid was formed (Solid P), as shown in this video: Mixing liquids. She recorded color, solubility, and density of the solids before and after mixing in Table 1.

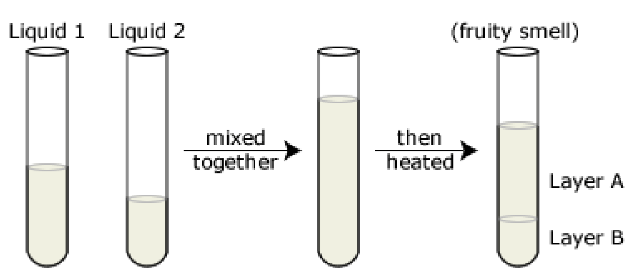
Table 1: Data of substances before and after mixing

| Solid | Color | Solubility in water | Density |
|---|---|---|---|
| A (before mixing it) | white | yes | 3.12 g/cm$^3$ |
| B (before mixing it) | white | yes | 4.53 g/cm$^3$ |
| P (after mixing) | yellow | no | 6.16 g/cm$^3$ |

#1 Look for a pattern in the data table to write a scientific explanation stating whether the yellow solid (Solid P) formed from Solid A and B was a chemical reaction.

Layers in a Test Tube

Miranda placed two liquids in a test tube. The two liquids were soluble in each other and mixed together. She then heated the test tube to see if the liquids would react. After heating the liquids, two separate layers formed - Layer A and Layer B.




Miranda tested and measured some properties of the liquids and layers and calculated the density of these substances, recording the data in Table 1.

Table 1. Data of sample before and after heating.

Student Investigation

Students will conduct an investigation to observe, analyze, and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.

Materials needed for this investigation:

- Pottery clay (non bake clay may also be used for ease like crayola brand[1])
- Water
- Charcoal or wood

Instructions: Prompt the students for the investigation by watching the video Pottery Techniques of Maria Martinez . Students are to work in pairs. They will knead and add water to make a firm but not soggy consistency of clay.

Student observation:

1. Describe the clay in appearance, texture, odor, texture and color.
2. Weight the clay sample and carefully ,measure the amount of water you used. Take turns with your partner kneading the clay.
3. Place your kneaded clay surrounded by charcoal or covered by wood , start a fire only with adult supervision.
4. The next day; compare your clay pot with other groups, you will ask them for the weight and amount of water they used. Divide the weight of clay with the amount of water to find the ratio.

| Name of other group | Weight/ mass of clay | Amount of water | Ratio (Weight / Water) | Noticeable characteristics |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |

5. Conclusions: Does the amount of water affect the final characteristics of the baked pot? Why or why not? Explain your answer in 3-5 sentences

1

| | Sample | Volume | Solubility in Water | Odor | Boiling Point | Density | Temperature |
|---|---|---|---|---|---|---|---|
| **Before Heating** | Liquid 1 | 0.45 $cm^3$ | Yes | alcohol | 78.4 ℃ | 0.79 $g/cm^3$ | 25 ℃ |
| | Liquid 2 | 0.35 $cm^3$ | Yes | vinegar | 118.5 ℃ | 1.05 $g/cm^3$ | 25 ℃ |
| **After Heating** | Layer A | 0.40 $cm^3$ | No | none | 77.1 ℃ | 0.90 $g/cm^3$ | 48 ℃ |
| | Layer B | 0.30 $cm^3$ | Yes | fruity | 100.0 ℃ | 1.00 $g/cm^3$ | 48 ℃ |

Use the data in Table 1 to answer the three questions below.

#1 State whether mixing and then heating Liquid 1 and Liquid 2 caused a chemical reaction to occur by relating the liquids before heating to the layers after heating.

#2 Describe what information from the data table you would use as evidence to support your claim and explain why you used it.

#3 Support your claim with evidence and reasoning using information in the data table.

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Jamie's salt and water experiment

Jamie arrived in chemistry class excited for "lab day". Jamie wanted to know whether salt and water chemically react when heated. Jamie did the following:

1. Measured mass and boiling point, and calculated the density of water and salt. Then recorded the data in Table 1.
2. Added a spoonful of salt to a container of room temperature water.
3. Stirred the water until he could no longer see the salt.
4. Boiled the mixture of salt and water and observed bubbles forming while a gas escaped from the test tube.
5. This gas was cooled and condensed into a liquid.
6. The heating continued until only a white solid was left.
7. Measured mass and boiling point, and calculated the density of the condensed liquid and white solid. Then recorded the data in Table 2.

Adapted from the Indigenous Wisdom Curriculum Project from the Indian Pueblo Cultural Center: [Indigenous Wisdom Curriculum Project | Indian Pueblo Cultural Center]

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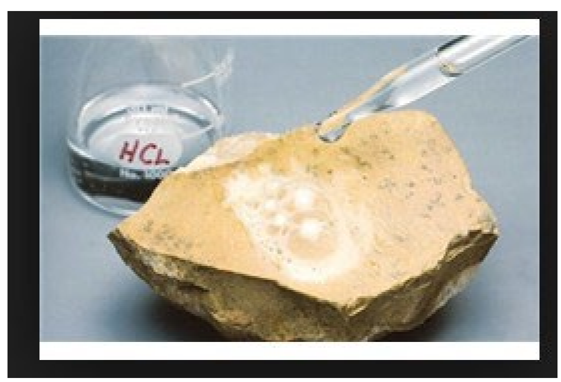
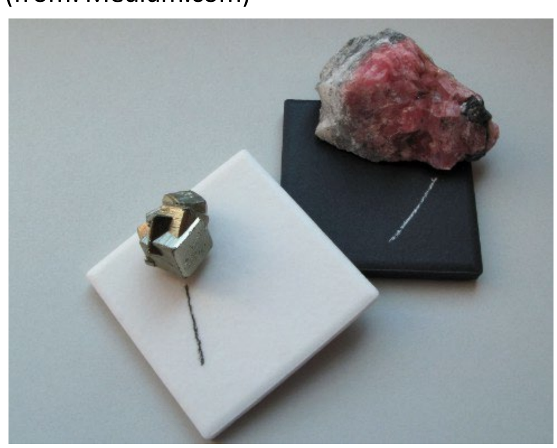
Student Investigation

Students will conduct an investigation to observe, analyze, and interpret data working to identify minerals rubbed each sample on a streak plate (a piece of unglazed porcelain). They recorded the color of the powder left on the plate. They then added 3 drops of dilute hydrochloric acid to each sample and recorded their observations.

Student observations:
Calcite produced a white streak and bubbles with the addition of HCl. Biotite produced no streak and no change was detected with HCl. Talc produced a white streak but no change with HCl. Quartz did not produce a streak and did not change with the addition of HCl. Galena had a charcoal gray streak and produced a strong odor of rotten eggs when HCl was added. (KScarff, BSMS)



(from: Medium.com)



From: Wikipedia

Table 1. **Before** Boiling

| Sample | Mass | Appearance | Boiling point | Density |
|---|---|---|---|---|
| Water | 20 g | clear, colorless | 98.9 °C | 0.98 g/cm$^3$ |
| Salt | 2 g | white clear crystal | too high for student thermometer to measure | 2.17 g/cm$^3$ |

Table 2. **After** Boiling

| Sample | Mass | Appearance | Boiling point | Density |
|---|---|---|---|---|
| Liquid | 20 g | clear, colorless | 98.9 °C | 0.98 g/cm$^3$ |
| White Solid | 2 g | white clear crystal | too high for student thermometer to measure | 2.17 g/cm$^3$ |

Using the data in Table 1 and Table 2, write a scientific explanation of whether a chemical reaction occurred. Make sure your explanation includes the three parts below.
#1 Make a claim on whether a chemical reaction occurred by relating the starting samples and the final samples after boiling.

#2 Show evidence to support your claim.

#3 Give reason(s) that the evidence you use supports your claim.

Sourced from Next Generation Science Assessment

1. Organize the students' observations from above by completing the data table.
2. Analyze the data to Identify minerals that show patterns of common characteristics.

3. Interpret the data:

a. Determine which of the minerals have a chemical reaction to hydrochloric acid and list them.
b. Provide the evidence to support your claim.

| **Minerals** | **Streak** | **Addition of HCl** |
|---|---|---|
| calcite | | |
| biotite | | |
| talc | | |
| quartz | | |
| galena | | |

| Change occurs with HCl | No Change with HCl | Minerals with Streak | Minerals without Streak |
|---|---|---|---|
| | | | |
| | | | |
| | | | |

Sourced from the Wonder of Science MS-PS1-2 Assessment - Chemical Reaction and Minerals (NY

| Culturally and Linguistically Responsive Instruction | | |
|---|---|---|
| *Validate and Affirm* | *Build and Bridge* | *Linguistic Vocabulary Support* |
| In your experience, how are interactions and reactions similar to and different from each other?<br><br>How does adding the word chemical change these meanings for you? | Why does this phenomenon matter to you or your community to understand what chemical reactions are? | Throughout the standard, students will be asked to analyze and interpret data on the properties of substances. Create the routine for physical science, to allow students to preview any learning material for unknown words.<br><br>Build a driving question board where students can stick questions and re-address their learning over time. Revisit this board often to help students make sense of their science learning. Bring those questions to group discussion.<br><br>Encourage students to work with vocabulary in meaningful ways. As students engage in sensemaking, students discuss complex ideas with everyday vocabulary and use many different verbal and non-verbal strategies to community their ideas. A common practice is to create an interactive "word wall" with students, with all the terms they have used when thinking and talking about the phenomena over the course of the unit. Overtime, teachers support, encourage, and/or require students to use proper terms as they ask questions, design experiments, and argue with evidence. Some vocabulary to utilize include: density, melting point, boiling point, solubility, flammability, and odor |

| Planning for Multi-Layer System of Support (MLSS) & Universal Design Learning | | |
|---|---|---|
| ***Layer 1*** ***Core Instruction + Universal*** | ***Layer 2*** ***Core + Targeted*** | ***Layer 3*** ***Core + Targeted + Intensive*** |
| *Instructional/Academic Supports* | | |
| **Activate or supply background knowledge:** Discuss the characteristic chemical and physical properties, such as density, melting point, boiling point, solubility, flammability, odor) of pure substance. Ask students to prior experience through visual imagery for each of the terms.<br><br>**Facilitate managing information and resources:** Use investigation data sets (data tables, graphs, etc) to discuss the differences between chemical and physical properties and changes with students. Use blank graphic organizers to help students collect and organize new data.<br><br>**Universal Design for Learning**<br>Representation<br>Engagement<br>Action and Expression<br>STEM Ready UDL Supports | **Facilitate managing information and resources:** Use *prepared* data sets (data tables, graphs, etc) to discuss the differences between chemical and physical properties and changes with students. Use blank graphic organizers to help students collect and organize new data.<br><br>**Increase mastery-oriented feedback:** This may help in a small group or while you are walking around monitoring students in pairs or work groups. Help students determine chemical and physical changes based on what they see in the data by providing specific feedback on what properties they're looking for and strategies to differentiate the properties. | Consider the misconceptions in content and skills needed within the PE and identify students for small group intervention. EX: Chemical changes always occur when substances are mixed/dissolved.<br><br>Students that are struggling with the concepts that chemical reactions occur anytime substances are struggling with the understanding of physical and chemical properties.<br><br>Ask students to draw on whiteboards, or scratch paper, solubility and what is happening with the particles.<br><br>**Facilitate managing information and resources:** Sometimes students have a hard time organizing data on a graph or table. Start with organizing data on a data table from one of the investigations. Leave the titles blank and work with students to insert the data in the correct place. It may benefit Layer 3 to have checklists to guide them in working through organizing data. |
| *Social Emotional Supports* | | |
| Integrate CASEL Playbook Strategies into your whole class routines or instruction. Some emphasized strategies/suggested activities are:<br>:<br><br>**Responsible Decision-Making, Relationship Skills, and Social Awareness:** While conducting investigations, utilize the Engaging with Data (p.24) protocol as a structured way to | Consider using the Layer 1 Engaging with Data protocol in a small group with teachers for students that are struggling with larger group settings like in lab work or partners.<br><br>Provide small-group support for students in need of focused skill instruction related to self-awareness, | Use the multi-layer PBIS Teach Relaxation Techniques to students that may be overwhelmed with data sets and organization of data.<br><br>Ensure that all learning environments allow students to thrive by considering the PBIS Sensory Tools.<br><br>Develop consistent Behavior Meetings to help build consistency and support for |

| | | |
|---|---|---|
| engage with data, with a focus on reflecting on implications and developing next steps.<br><br>Students will go through four main steps: predictions, descriptions, interpretations, and implications. | self-management, social awareness, relationship skills, and responsible decision making.<br><br>Increase positive reinforcement within the classroom for positive behavior. | the students.<br><br>Additional student stakeholders may offer additional support through Counselor Referral or Collaboration with a student's physician or mental health provider. |
| | *Behavioral Supports* | |
| For all students, the use of Redirection helps build a productive learning environment with minimizing distractions to help improve student attention and focus.<br><br>For all students, the use of Clear, consistent, and predictable consequences helps build a productive learning environment. | Ensure the use of a PBIS Behavior Contract during lab investigations and hands-on learning to ensure Layer 1 routines are supported.<br><br>With challenging academic learning, utilize PBIS Structured Breaks throughout the learning cycle to support the multi-sensory environment of phenomena-based science. | Consider the PBIS strategy for Forced Choice Reinforcement Survey to gain insight for working with specific students on their incentives.<br><br>Utilize the PBIS Check In Check Out (CICO) to engage all student stakeholders in creating a consistent learning environment. |

| **Cross-Curricular Connections** | |
|---|---|
| *ELA/Literacy* | *Mathematics* |
| **RST.6-8.1:** Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.(MS-PS1-2)<br><br>**RST.6-8.7:** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-PS1-2) | **MP.2** Reason abstractly and quantitatively. (MS-PS1-2)<br>6.RP.A.3 Use ratio and rate reasoning to solve real-world and mathematical problems. (MS-PS1-2)<br><br>**6.SP.B.4** Display numerical data in plots on a number line, including dot plots, histograms, and box plots. (MS-PS1-2)<br><br>**6.SP.B.5** Summarize numerical data sets in relation to their context. (MS-PS1-2) |

| | |
|---|---|
| After experiencing the phenomenon and conducting some investigations, engage students in creating a flowchart that represents their understanding of physical and chemical properties and how they know whether or not a chemical reaction occurred. | Density is an abstract concept for students to grasp. Use the PhET Density simulation for students to explore. Have students identify the variables for an object as density, mass, and variable.<br><br>Students should explore and be able to explain why changing an object's mass or volume does not affect its density.<br><br>To explore more about melting and boiling points, there is also a PhET States of Matter: Basics simulation. Students can investigate and collect temperature data in various ways to predict how varying the temperature changes the behavior of particles. |

| *Career & Skill Connections* | |
|---|---|
| Anthropology<br>Biology<br>Chemistry<br>Geology<br>Engineering | Farming<br>Meteorology |

| Grade | NGSS Discipline Overview |
|---|---|
| **MS** | **Physical Science** |
| **Click to find the standards breakdown.** | **Teacher Background by Performance Expectation (PE)** |
| **PS1-3** | Students will investigate and gather information on synthetic materials by researching from at least two reliable sources (text, media, data, etc.). Their focus will be on:<br>● How synthetic materials are derived from natural resources (e.g., concrete from limestone) and the chemical transformations they undergo. These are the chemical processes used to create these materials (e.g., burning limestone). They'll learn that synthetic materials are created by chemically changing natural resources, like turning oil into plastic. This is different from simply using a natural resource like wood.<br><br>By evaluating the information they gather (relevance, accuracy, bias), students will:<br>● Describe how synthetic materials are formed, from the natural resource to the final product. This includes the chemical processes involved.<br>● Explain how the synthetic material's properties differ from its natural source.<br>● Connect the material's properties to its specific function (e.g., plastic's durability for packaging) and understand how these materials fulfill societal needs based on their structure and function.<br>● Analyze the environmental and societal effects of producing and using synthetic materials to answer why these materials are important (e.g., concrete for building). |

| Standards Breakdown | | | | |
|---|---|---|---|---|
| MS | Physical Science 1.3 | | | |
| PS1-3 | *The performance expectation below was developed using the following elements from the NRC document, A Framework for K-12 Science Education* | | | |
| | **MS-PS1-3: Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.**<br><br>**Clarification Statement:** Emphasis is on natural resources that undergo a chemical process to form the synthetic material. Examples of new materials could include new medicine, foods, and alternative fuels.<br><br>**Assessment Boundary:** Assessment is limited to qualitative information. | **SEP**<br><br>**Obtaining, Evaluating, and Communicating Information**<br>Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or now supported by evidence. | **DCI**<br><br>**PS1.A: Structure and Properties of Matter**<br>• Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.<br><br>**PS1.B: Chemical Reactions**<br>• Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. | **CCC**<br><br>**Structure and Function**<br>• Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.<br><br>**Interdependence of Science, Engineering, and Technology**<br>• Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineered systems.<br><br>**Influence of Science, Engineering and Technology on Society and the Natural World**<br>• The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time. |
| | *These standards are not meant to be taught individually on their own, but bundled with other standards. Bundles are groups of standards arranged together to create endpoints for instruction and it helps students see connections between concepts and allow more efficient use of instructional time. Work with your local school, or district, on creating bundles for your middle school science courses or you can utilize resources and guidance from NMPED.* | | | |
| | **Common Misconceptions** | | | |

| | | | |
|---|---|---|---|
| | • All synthetic materials are made up of polymers.<br>• Synthetic materials are more toxic than natural materials.<br>• Synthetic materials are always beneficial to society.<br>• Synthetic chemicals are more toxic than natural chemicals. | • Synthetic copies of natural chemicals are not as good for you.<br>• Chemical-free products are safer<br>• If you can't pronounce it, it's bad for you<br>• Organic products are better than synthetic products<br>• Nanoparticles are harmless<br>• You can lead a chemical-free life | • Synthetic chemicals are causing many cancers and other diseases<br>• Our exposure to a cocktail of chemicals is a ticking time-bomb<br>• It is beneficial to avoid man-made chemicals<br>• We are subjects in an unregulated, uncontrolled experiment<br>• Organically grown food is better for you because it's all natural. |
| | **New Mexico Relevant Phenomena** | | |
| | *When available, you should use your locally selected or created high quality instructional materials. However, the following is an example phenomenon you can use if you don't have local high quality instructional materials available.* | | |
| | *How did you know if you made a new material/food after combining and processing the ingredients?* | *Why do people turn natural materials into synthetic materials? How does this impact your daily life?* | |

Everyone likes edible science phenomena. This phenomenon is a continuation of the elementary slime making laboratory in chemical reactions. The properties of the reactants can be compared to the properties of the products to show that a chemical reaction has occurred. Have some gummy worms available for students to view prior to watching the video and asking them, how are gummy worms made, or what ingredients are used to make gummy worms? Show students the video in class and then discuss the differences between their prior answers and the video.

There is an added opportunity for learning and developing social skills in class so that the students have some freedom to modify the ratios of the ingredients and keep notes. This will result in variations of smells, tastes and texture of the edible worms. Students can then go around, share and sample different worms and discuss the ratios other students used.

Adapted from the Wonder of Science

*Why do we need to recycle the plastics that we use?*

Consider sorting the plastic they are about to throw in their household/school into PET, HDPE, PVC, LDPE, PP, PS and others (be sure to follow safety procedures, like pre-sorting school materials for sharp objects, gloves, and handwashing). Students can then make generalizations or assumptions about what types of plastics are being used for specific purposes like for example in disposable water bottles is PET, PC, or HDPE. These labels are usually found at the bottom of the container or

After looking at photos of crystal gypsum and the open-cut gypsum mine, show students the video on how drywall is made. How Gypsum Board (Drywall) Is Made

Ask students to consider what some of the environmental impacts that both gypsum mining and drywall production might cause. (habitat disruption, waste water from drywall production, waste material from mining). Lead students in a discussion about those impacts.

An example of a natural material (mineral) mined in New Mexico and turned into a synthetic material is labeled in the plastic itself with a triangle logo. After exploring some of the plastics, have students watch the video Precious Plastic V2 - Promo to hold a discussion on the ease of repurposing plastics and how we use them for single uses.

Precious Plastics was created in 2013 by Dave Hakkens. It is a website that shares DIY plans for building machines that can recycle plastic. Plastic is recreated through a non-reversible reaction and if it isn't recycled this valuable plastic is often lost forever when it is dumped in a landfill. These plans have spawned a community of DIY plastic recyclers around the world.

Adapted from the Wonder of Science Precious Plastic

*What are sources of pollution in your community? How are plastics made and what are possible solutions for reducing plastic waste?*

Use similar sorting examples from previous phenomena to bring awareness of individual waste and behaviors about what and how we throw items away. Begin a discussion from this phenomenon to guide students to identify where their trash goes and possible effects it can have on the environment.

Sourced from NGSS Quality Examples of Science Lessons and Units Middle School: Aspire Public Schools: An Ocean of Plastics | Next Generation Science Standards

gypsum. Gypsum is commonly mined in New Mexico and can be processed into synthetic materials such as drywall or plasterboard, which are widely used in construction for interior walls and ceilings. The gypsum mined from natural deposits undergoes the process of calcination* to create synthetic gypsum, which has similar properties to natural gypsum and is used as a key component in manufacturing construction materials. This process highlights the connection between natural resources like gypsum and the production of synthetic materials that impact various aspects of society, including construction, infrastructure, and housing.

*(Calcination involves heating the gypsum at high temperatures (around 150-165 degrees Celsius or 300-350 degrees Fahrenheit) in order to remove the water of crystallization from the gypsum and convert it into a different chemical form known as calcium sulfate hemihydrate, also known as plaster of Paris.)

Some initial investigations/conversations with students could involve: environmental impacts of mining gypsum in NM, economic impact of gypsum production, and how much gypsum we use in daily life.

**More information:** THE MINING INDUSTRY IN NEW MEXICO

## Classroom Assessment Items

*When available, you should use your locally selected or created high quality instructional materials. However, the following is an example phenomenon you can use if you don't have local high quality instructional materials available.*

Natural vs. Synthetic Materials Summative Instructions + Rubric

Directions: For this summative task, you will be reading, gathering, and synthesizing information evidence to answer the following questions about the synthetic product of your choice:

1) What is the synthetic material?
2) What is the importance to humans? *(Why do humans use/make it?)*
3) What natural resources are used to make the synthetic material?
4) What are the atomic structures of the reactants and the synthetic product?
5) How is the synthetic material made? *(What chemical process(es) are used to create the product?)*
6) What are the negative and positive impacts/effects of making and using the synthetic material, compared to making and/or using a more natural material with a similar function?

Once you have completed your research, you will make a scientific poster about your findings. Your poster must include:

- all necessary requirements,
- citations for at least two sources,
- evidence that your chosen sources are reliable,
- and a neat and professional appearance.

Consult the rubric and exemplars to help guide you during this assessment.

The Good, The Bad, and the Ugly

You are invited to a party at your friend's house and your friend doesn't want to wash the dishes afterwards. Your friend has two different types of plates to choose from.

**Table 1: Comparison of Sugarcane Plate and Styrofoam Plate**

| | Sugarcane Plate | Styrofoam Plate |
|---|---|---|
| Picture |  |  |
| Natural vs Synthetic | Natural | Synthetic |
| What it's made from | dry pulpy fibrous material that remains after crushing sugarcane (sugarcane is a plant used to make sugar) | Natural gas changed into plastic foam |
| Properties | strong,<br>grease and cut resistant | heat resistant<br>light weight<br>sturdy |
| Cost | Case of sugarcane takeout boxes is $64 | Case of styrofoam takeout boxes is $24 |
| Other Uses | Paper, cardboard, sugar, polishes, insulation, biofuel | Insulator, packing materials, hot cocoa cups, take out containers |
| How it decomposes | Video Link | |

Table 1 compares the properties of sugarcane plate and styrofoam plate.

Your Task

In the questions that follow, you will obtain and evaluate information from the data table to describe the functions, role in society, and effects of sugarcane and styrofoam plates on the environment.

Question 1

Synthetic materials come from ____________________ materials.

What natural materials are found in both plate types?

Question 2

Exemplar (Full Page PDF link)

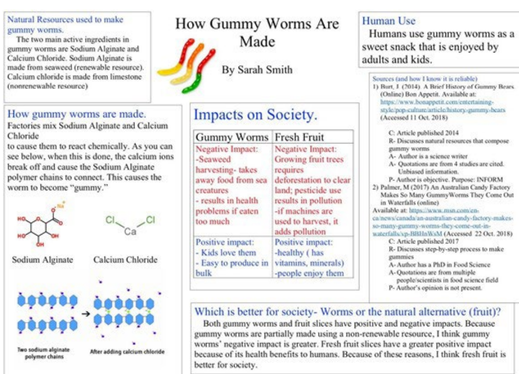
Sourced and adapted from the Wonder of Science MS-PS1-3 Assessment - Natural vs Synthetic Materials

1. What are the natural resources used to make gummy worms?
2. How gummy worms are made? Draw and label the molecules
3. Impact to society

| | Gummy Worms | Fresh Fruit |
|---|---|---|
| Positive Impact | | |
| Negative Impact | | |

4. What are the common uses of gummy worms?
5. Which is better for society: Gummy worms or natural alternatives (fruit). Defend your answer using 3-5 sentences?

ANSWER KEY:



Natural Resources used to make gummy worms.
The two main active ingredients in gummy worms are Sodium Alginate and Calcium Chloride. Sodium Alginate is made from seaweed (renewable resource). Calcium chloride is made from limestone (nonrenewable resource)

How Gummy Worms Are Made
By Sarah Smith

Human Use
Humans use gummy worms as a sweet snack that is enjoyed by adults and kids.

How gummy worms are made.
Factories mix Sodium Alginate and Calcium Chloride
to cause them to react chemically. As you can see below, when this is done, the calcium ions break off and cause the Sodium Alginate polymer chains to connect. This causes the worm to become "gummy."



Impacts on Society.

| Gummy Worms | Fresh Fruit |
|---|---|
| Negative Impact: -Seaweed harvesting- takes away food from sea creatures - results in health problems if eaten too much | Negative Impact: Growing fruit trees requires deforestation to clear land; pesticide use results in pollution -if machines are used to harvest, it adds pollution |
| Positive impact: - Kids love them - Easy to produce in bulk | Positive impact: -healthy ( has vitamins, minerals) -people enjoy them |

Sources (and how I know it is reliable)
1) Burt, J. (2014). A Brief History of Gummy Bears (Online) Bon Appetit. Available at: https://www.bonappetit.com/entertaining-style/pop-culture/article/history-gummy-bears (Accessed 11 Oct. 2018)
C: Article published 2014
R- Discusses natural resources that compose gummy worms
A- Author is a science writer
A- Quotations are from 4 studies are cited. Unbiased information.
P- Author is objective. Purpose: INFORM
2) Palmer, M (2017) An Australian Candy Factory Makes So Many GummyWorms They Come Out in Waterfalls (online)
Available at: https://www.msn.com/en-ca/news/canada/an-australian-candy-factory-makes-so-many-gummy-worms-they-come-out-in-waterfalls/vp-BBHInWsM (Accessed 22 Oct. 2018)
C: Article published 2017
R- Discusses step-by-step process to make gummies
A- Author has a PhD in Food Science
A- Quotations are from multiple people/scientists in food science field
P- Author's opinion is not present.

Which is better for society- Worms or the natural alternative (fruit)?
Both gummy worms and fruit slices have positive and negative impacts. Because gummy worms are partially made using a non-renewable resource, I think gummy worms' negative impact is greater. Fresh fruit slices have a greater positive impact because of its health benefits to humans. Because of these reasons, I think fresh fruit is better for society.

Sourced from the Wonder of Science Gummy worms

Study Table 1 above.

What beneficial (good) properties do each of the plate types have? Complete the table below:

| Beneficial properties of the **sugarcane** plate: | Beneficial properties of the **styrofoam** plate: |
|---|---|
| | |
| | |
| | |

Question 3
Study Table 1 above and watch the video, "How it Decomposes."

Using the data from Table 1 and the video "How it Decomposes", evaluate which plate's properties would be better for society. Use evidence to support your answer.

Question 4
If you were at this party, which plate would you choose to use and why? Think about the following:
1. Function of the plate
2. How using that plate affects society/environment

Make sure you address both 1 and 2 in your answer and use evidence to support your claim.

Sourced from Disposable Plates SEEd 8.1.4 Formative Assessment

| **Culturally and Linguistically Responsive Instruction** | | |
|---|---|---|
| *Validate and Affirm* | *Build and Bridge* | *Linguistic Vocabulary Support* |

| | | | |
|---|---|---|---|
| | What does the word synthetic mean to you, your family, or your community?<br><br>When you hear that something is synthetic, how do you react? | Can you think of any examples of synthetic products that improve your life or your community's lives?<br><br>Build a Driving Question Board where students can add their questions and re-address their learning through time. Revisit this board often to help students make sense of their science learning. | Throughout the standard, students will be asked to gather and make sense of information to describe that synthetic materials come from natural resources and impact society. Create the routine for physical science, to allow students to preview any learning material for unknown words. Provide the meaning with no judgment or reference to other learning material.<br>**Best practice when this happens is for the teacher to keep a running record of the words and frequency.*<br><br>Build a driving question board where students can stick questions and re-address their learning over time. Revisit this board often to help students make sense of their science learning. Bring those questions to group discussion.<br><br>Encourage students to work with vocabulary in meaningful ways. As students engage in sensemaking, students discuss complex ideas with everyday vocabulary and use many different verbal and non-verbal strategies to community their ideas. A common practice is to create an interactive "word wall" with students, with all the terms they have used when thinking and talking about the phenomena over the course of the unit. Overtime, teachers support, encourage, and/or require students to use proper terms as they ask questions, design experiments, and argue with evidence. Some vocabulary includes: chemical processes, synthetic materials (list specific ones), natural resources, physical and chemical properties, reactant, structure and function, and societal needs |
| | **Planning for Multi-Layer System of Support (MLSS) & Universal Design Learning** | | |
| | ***Layer 1***<br>***Core Instruction + Universal*** | ***Layer 2***<br>***Core + Targeted*** | ***Layer 3***<br>***Core + Targeted + Intensive*** |
| | *Instructional/Academic Supports* | | |

| | | | |
|---|---|---|---|
| | **Foster collaboration and community:** Throughout instruction, create various opportunities for learning groups with clear goals, roles, and responsibilities for students to follow. Encourage at the beginning of instruction, through the phenomenon,<br><br>**Heighten salience of goals and objectives:** Some learners need support to remember the initial goal. It is important to build persistent reminders of goals and its value in order for students to sustain effort and concentration.<br><br>Students should also be able to determine the credibility, accuracy, and possible bias of each source of information, including the ideas included and methods described.<br><br>**Universal Design for Learning**<br>Representation<br>Engagement<br>Action and Expression<br>STEM Ready UDL Supports | **Facilitate managing information and resources:** Use *prepared* data sets (data tables, graphs, etc) to discuss the differences between chemical and physical properties and changes with students. Use blank graphic organizers to help students collect and organize new data.<br><br>Support may include helping students understand the process to create these synthetic materials. | **Offer alternatives for visual information:** Students may also struggle with the concept of synthetic materials. To ensure that all learners have equal access to information, it is essential to provide non-visual alternatives like Use touch equivalents (tactile graphics or objects of reference) for key visuals that represent concepts.<br>● Provide descriptions (text or spoken) for all images, graphics, video, or animations<br>● Use touch equivalents (tactile graphics or objects of reference) for key visuals that represent concepts<br>● Provide physical objects and spatial models to convey perspective or interaction:<br><br>**Facilitate managing information and resources:** Sometimes students have a hard time organizing information from multiple research sources. Consider using a partial completed graphic organizer for students to see patterns and complete the missing information for their research. It may benefit Layer 3 to have checklists to guide them in working through organizing data. |
| | *Social Emotional Supports* | | |
| | Integrate CASEL Playbook Strategies into your whole class routines or instruction. Some emphasized strategies/suggested activities are:<br><br>**Relationship Skills:** Consider having students complete the Cross-Curricular ELA/literacy connection to utilize the strategy Maitre d' (p.30) where | **Self-Awareness, Relationship Skills and Responsible Decision-Making:** After introducing the phenomenon, utilize the strategy Pass It On (p.31). This activity would be for students to share ideas with each other in a quiet, focused way. It is particularly useful after a round of active engagement. | Use the multi-layer PBIS Teach Relationship Skills to students that may be struggling with interpersonal skills during the gathering of information from this standard.<br><br>Ensure that all learning environments allow students to thrive by considering the PBIS Sensory Tools. |

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| | the teacher facilitator calls participants to form 'tables' where they 'dine' (exchange ideas) with a variety of tablemates. This activity helps participants develop a sense of connectedness when sharing ideas, encourages listening to a wide range of ideas, and incorporates movement and fluid grouping. | Provide small-group support for students in need of focused skill instruction related to self-awareness, self-management, social awareness, relationship skills, and responsible decision making.<br><br>Increase positive reinforcement within the classroom for positive behavior. | Develop consistent Behavior Meetings to help build consistency and support for the students.<br><br>Additional student stakeholders may offer additional support through Counselor Referral or Collaboration with a student's physician or mental health provider. |
| | *Behavioral Supports* | | |
| | For all students, the use of Clear, consistent, and predictable consequences helps build a productive learning environment.<br><br>Ensure the use of a PBIS Behavior Contract during lab investigations and hands-on learning to ensure Layer 1 routines are supported. | Ensure the use of a PBIS Behavior Contract during lab investigations and hands-on learning to ensure Layer 1 routines are supported.<br><br>With challenging academic learning, utilize PBIS Structured Breaks throughout the learning cycle to support the multi-sensory environment of phenomena-based science. | Utilize the PBIS Check In Check Out (CICO) to engage all student stakeholders in creating a consistent learning environment. |
| | **Cross-Curricular Connections** | | |
| | *ELA/Literacy* | *Mathematics* | |
| | **RST.6-8.1:** Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. (MS-PS1-3)<br><br>**WHST.6-8.8** Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation. (MS-PS1-3) | **None** | |

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| Read this interview Nick Robertson Thinks We Need to Rethink Plastic - Northland College as the background knowledge/text for the statement posed on the mathematics activity.<br><br>Encourage students to investigate their synthetic product using internet and library resources. After students know the product they will research, remind them to look for the following information:<br>1. What natural resources are used to make the synthetic product?<br>2. What chemical processes are used to make the synthetic product?<br>3. What are the negative and positive impacts to society of making and using the synthetic product, compared to making and using a more natural product with a similar function?<br><br>Encourage students to use the findings from their research to conclude whether the positives outweigh the negatives. If they would need more information to make that decision, ask students to identify what they would need to know.<br><br>Sourced from Project Based Lessons: Natural Resources & Synthetic Materials - American Chemical Society | Suggested math practices to utilize:<br>**MP.2** Reason abstractly and quantitatively.<br><br>**MP.4** Model with mathematics.<br><br>Post the following statement on the board or projector to students: *Global use of plastic has increased twenty-fold over the past fifty years and is expected to double again in the next twenty years. Research shows there will be more plastic than fish by weight in the world's oceans by 2050.*<br><br>Encourage students to ask questions and generate some wonders. Ask students to consider their daily use of products. Discuss with students how based on daily calculations of use (focusing on ratio and rate reasoning), that scientists can make the statement, especially, *"Research shows there will be more plastic than fish by weight in the world's oceans by 2050."*<br><br>Preview this site and the various calculators on which/how to individualize the calculators you want to use in your classroom, but consider modeling and leading students through the first few Plastic Calculator.<br><br>Ask students to think about the accuracy of the calculations and to attempt to write some expressions of their entries into the calculator. |

*Career & Skill Connections*

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| Atmospheric science<br>Biology<br>Chemistry<br>Conservation science<br>Engineering<br>Environmental economist | Landscape architecture & design<br>Mechanical engineering<br>Solar energy systems engineering<br>Transportation management<br>Urban planning |

| Grade | NGSS Discipline Overview |
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| MS | Physical Science |
| Click to find the standards breakdown. | **Teacher Background by Performance Expectation (PE)** |
| PS1-4 | To make sense of a given phenomenon, students develop a model to understand the relationships between particles, energy, and temperature. In the model, students identify key components: particles (their motion), the system they're in, thermal energy, temperature, and states of matter (solid, liquid, gas).<br><br>Students will need to use the models to make causal accounts. A causal account is an explanation that focuses on identifying cause-and-effect relationships between events or phenomena. It describes how one thing (the cause) brings about another thing (the effect). It explains why or how something happens by identifying the cause that triggers the effect. A strong causal account is supported by evidence, such as observations, experiments, or data analysis. This evidence helps to establish a clear connection between the cause and the effect.<br><br>Everything around us is made of tiny particles, most commonly atoms or molecules (groups of atoms bonded together). These particles are constantly in motion, vibrating or moving around. The speed and type of motion depend on the temperature. This is the total energy of the random motion of the particles within the system. Higher temperatures indicate higher thermal energy (faster moving particles). This is a measure of the average kinetic energy (energy of motion) of the particles in a system. It's important to note that temperature is not the same as thermal energy. A large pot of water at a certain temperature will have more thermal energy than a small cup of water at the same temperature because there are more particles in the pot. Depending on the amount of thermal energy (particle motion), matter can exist in different states: solids have the least motion, vibrating in fixed positions with minimal space between them; liquids have more motion than in a solid, able to move around each other but still relatively close together. Gases have the most motion, moving freely with large spaces between them.<br><br>By understanding these components and their interactions, the model helps students explain how thermal energy changes can cause particles to move faster or slower, potentially leading to changes of state (e.g., ice melting into water, water boiling into steam). Students will use the model to explain how adding or removing thermal energy affects a substance:<br>● Increased energy can raise temperature, cause a change of state (solid to liquid, liquid to gas), or increase pressure (gas molecules collide with more force).<br>● Decreased energy can lower temperature, cause a change of state (gas to liquid, liquid to solid), or decrease pressure (gas molecules collide with less force).<br><br>Students will also explain and account for how pressure changes can affect changes of state:<br>● Lower pressure allows liquids to change to gas more easily (fewer collisions from gas molecules on the liquid's surface).<br>● Higher pressure makes it harder for liquids to change to gas (more collisions from gas molecules on the liquid's surface). |

| Standards Breakdown | | | | | |
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| MS | **Physical Science 1.4** | | | | |
| **PS1-4** | *The performance expectation below was developed using the following elements from the NRC document, A Framework for K-12 Science Education* | | | | |
| | **MS-PS1-4: Develop a model** | **SEP** | **DCI** | **CCC** | |

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| | **that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.**<br><br>**Clarification Statement:** Emphasis is on qualitative molecular-level models of solids, liquids, and gases to show that adding or removing thermal energy increases or decreases kinetic energy of the particles until a change of state occurs. Examples of models could include drawing and diagrams. Examples of particles could include molecules or inert atoms. Examples of pure substances could include water, carbon dioxide, and helium.<br><br>**Assessment Boundary:** None | **Developing and Using Models**<br>Modeling in 6–8 builds on K–5 and progresses to developing, using and revising models to describe, test, and predict more abstract phenomena and design systems.<br>• Develop a model to predict and/or describe phenomena. | **PS1.A: Structure and Properties of Matter**<br>• Gases and liquids are made of molecules or inert atoms that are moving about relative to each other.<br>• In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations.<br>• The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter.<br><br>**PS3.A: Definitions of Energy**<br>• The term “heat” as used in everyday language refers both to thermal energy (the motion of atoms or molecules within a substance) and the transfer of that thermal energy from one object to another. In science, heat is used only for this second meaning; it refers to the energy transferred due to the temperature difference between two objects. (secondary)<br>• The temperature of a system is proportional to the average internal kinetic energy and potential energy per atom or molecule (whichever is the appropriate building block for the system’s material). The details of that relationship depend on the type of atom or molecule and the interactions among the atoms in the material. Temperature is not a direct measure of a system's total thermal energy. The total thermal energy (sometimes called the total internal energy) of a system depends jointly on the temperature, the total number of atoms in the system, and the state of the material. (secondary) | **Cause and Effect**<br>• Cause and effect relationships may be used to predict phenomena in natural or designed systems. |
| | *These standards are not meant to be taught individually on their own, but bundled with other standards. Bundles are groups of standards arranged together to create endpoints for instruction and it helps students see connections between concepts and allow more efficient use of instructional time. Work with your local school, or district, on creating bundles for your middle school science courses or you can utilize resources and guidance from NMPED.* | | | |
| | **Common Misconceptions** | | | |

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| | • Pressure and force are synonymous.<br>• Liquids rise in a straw because of "suction."<br>• Heating air only makes it hotter.<br>• Heat is a substance.<br>• Heat is not energy.<br>• The temperature of an object depends on its size.<br>• Boiling is the maximum temperature a substance can reach.<br>• Heat and cold are different, rather than being opposite ends of a continuum. | • The bubbles in boiling water contain "air," "oxygen," or "nothing," rather than water vapor.<br>• Gases are not matter because most are invisible.<br>• Gases do not have mass.<br>• Expansion of matter is due to expansion of particles rather than to increased particle spacing.<br>• Particles of solids have no motion.<br>• Melting/freezing and boiling/condensation are often understood only in terms of water.<br>• Particles are viewed as mini-versions of the substances they comprise.<br>• Ice cannot change temperature. | • Particles are often misrepresented in sketches. No differentiation is made between atoms and molecules.<br>• Particles misrepresented and undifferentiated in concepts involving elements, compounds, mixtures, solutions and substances.<br>• Frequent disregard for particle conservation and orderliness when describing changes.<br>• Temperature is a property of a particular material or object——metal is naturally cooler than plastic. |
| | **New Mexico Relevant Phenomena** | | |
| | *When available, you should use your locally selected or created high quality instructional materials. However, the following is an example phenomenon you can use if you don't have local high quality instructional materials available.* | | |
| | *How can we model and explain the difference between things being hot or cold?* | *What causes a hot air balloon to rise and fall?* | |
| | This HQIM phenomenon is also used in ESS1-1 | | |

and provides an example of bundling standards for students to see connections between concepts.

Provide students with two candies (those that have dyes on the outside and are small like Skittles or M&Ms). Provide students clear cups of hot and cold water. Instruct students to drop one piece in each cup of water and observe. Candy breaks into pieces and dissolves more quickly in hot water than cold water. Food coloring moves around and spreads out more in hot water than cold water. When water is shaken vigorously, the water warms up.

Start a discussion about what students are observing and what they think is happening. See if any students could create a drawing of what happened. Ask students what might be happening at the particle level that we can't see. During the discussion, do not correct student ideas or misuse

of language. This time should be used to share all thinking and make connections.

Sourced from Open Sci Ed Lesson 10 6.2 Thermal Energy

*How do atoms or molecules move if you add or remove heat?*

Watch this video on Convection Paper Spiral Science Experiment and have some paper spinners prepared for your students to investigate. Have students cut some templates of spinners and create a safety area where they can demonstrate while the teacher strictly monitors.

Convection currents are shown with candle and paper spinner. The paper spinner spins because of the movement of hot air being pushed up from the lighted candle.

Afterwards, have students discuss, either the whole group or in partners, what they observed and how they might be able to create a model drawing of how the paper moved.

NM Hot Air Balloon Festival

Imagine observing a hot air balloon gearing up for flight. As the pilot ignites the burner, something remarkable happens inside the balloon. The heat (thermal energy) energizes the air particles, making them move faster and collide more often. This increased motion causes the air inside to expand, much like a normal balloon inflating.

With this expansion, the air becomes less dense than the surrounding air. This difference in density creates a buoyant force that pushes the balloon upward. So, just like a balloon filled with helium rises because it's lighter, a hot air balloon rises because the heated air inside is lighter and wants to go up. It's a fascinating demonstration of how thermal dynamics work in real life.

Show students the timelapse video from the 2023 Albuquerque Balloon Fiesta 4K Timelapse. Encourage students to share their experiences or stories with the festival. Ask students can draw a cross section of a hot air balloon, with warmer air at the top and cooler air at the bottom. Particles are farther apart at the top of the balloon (less dense) and closer together at the bottom of the balloon (more dense). Gradually as the air heats up, the particles throughout the balloon move more quickly and are farther apart.

Discussions can center on exploring how changes in temperature affect the behavior of air particles, investigating the role of buoyancy in the balloon's ascent, analyzing the relationship between heat transfer and altitude control.

**Classroom Assessment Items**

*When available, you should use your locally selected or created high quality instructional materials. However, the following is an example phenomenon you can use if you don't have local high quality instructional materials available.*

Melting Butter
A piece of solid butter is placed in a pan on a stove and gently heated, causing thermal energy to transfer to the butter until the state of the butter changed.


Butter before heating

Butter after heating

Construct a model that shows the butter particles **before** and **after** thermal energy is **transferred to** the solid butter by heating. Be sure your model includes pictures and a key to show the thermal energy and kinetic energy of the motion of the particles. Also, predict the change in the state of solid butter. Provide space for drawing a model.

Write a description of what your model shows. In your description, explain how the state of the solid butter changes after thermal energy is transferred to butter by heating.

Sourced from Wonder of Science [MS-PS1-4 Assessment - Melting Butter]

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Hot Shower Effect
While taking a hot shower, Simone wondered what would happen to the water vapor from her hot shower once it came in contact with the cold mirror.

Hot Air Only
Each year. Albuquerque hosts the International Balloon Festival. Brandon got to experience the festival in person this year, although he didn't ride any balloons, he saw many of them getting set up, lifting off the ground, and flying in the air. He was

Question 1: Construct a model that shows what happens to the molecules inside the balloon when it ascends into the air (remember to think about molecules outside the balloon too). Be sure your model includes pictures and a key that shows the thermal energy and kinetic energy of the motion of the air molecules. Also, predict the state of the molecules once a pilot decides to descend.

Write a description of what your model shows. Jane's

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Inflated Ball
One cold morning, Jane went to the gym to get a ball. She noticed the ball felt slightly flat when she squeezed it. She left the ball outside on a hot sunny day until after school. When Jane picked it up after school and squeezed it, she noticed that the ball seemed more inflated than when it was indoors at a low temperature.

She wondered why the ball seemed more inflated after school in the hot Sun when she did not fill it up with air.

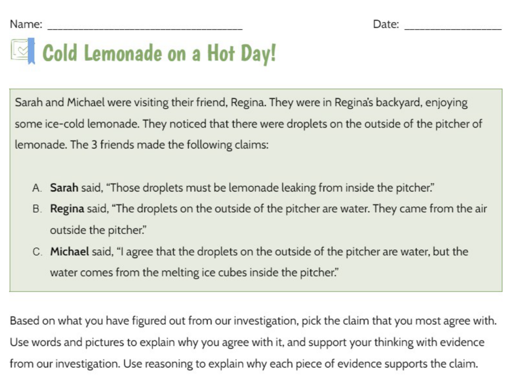
Construct a model that shows why the ball became inflated outdoors on a hot sunny day (at a high temperature) and why it was flatter indoors on a cold morning (at a low temperature). Your model should show what is different about the molecules in the ball outdoors and indoors with different temperatures. Be sure your model includes pictures and a key.

Write a description of what your model shows. Sourced

Question 1: Construct a model that shows what would happen to the water molecules from Simone's shower once the water vapor hits the cold mirror. Be sure your model includes pictures and a key that shows the thermal energy and kinetic energy of the motion of the water molecules. Also, predict the state of water vapor once it comes in contact with the cold mirror.

Write a description of what your model shows. In your description, explain how the state of water vapor changes after it hits the cold mirror.

Sourced from Next Generation Science Assessment Cold Lemonade on a Hot Day


Name: ______________________ Date: ____________

Cold Lemonade on a Hot Day!

Sarah and Michael were visiting their friend, Regina. They were in Regina's backyard, enjoying some ice-cold lemonade. They noticed that there were droplets on the outside of the pitcher of lemonade. The 3 friends made the following claims:

A. **Sarah** said, "Those droplets must be lemonade leaking from inside the pitcher."
B. **Regina** said, "The droplets on the outside of the pitcher are water. They came from the air outside the pitcher."
C. **Michael** said, "I agree that the droplets on the outside of the pitcher are water, but the water comes from the melting ice cubes inside the pitcher."

Based on what you have figured out from our investigation, pick the claim that you most agree with. Use words and pictures to explain why you agree with it, and support your thinking with evidence from our investigation. Use reasoning to explain why each piece of evidence supports the claim.

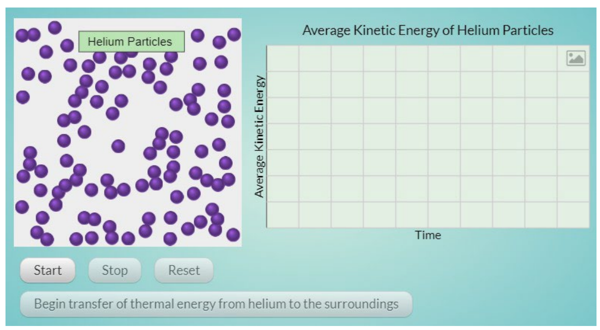
Sourced from Open Sci Ed Lesson 5 6.2 Lesson 5 Assessment Cold Lemonade on

from Next Generation Science Assessment Justin's Deflated Balloon

*Note: This assessment item includes an interactive simulation that will require students to use technology.*

Justin has a balloon filled with helium gas that is at room temperature (20 °C). He wondered how the temperature of the gas inside the balloon would change if he took the balloon outdoors on a cold day (5 °C).

Justin cannot measure the temperature of the helium in the balloon without releasing the helium from the balloon. Instead, he can use the simulation to see what would happen to the motion of the helium particles in the balloon to figure out the temperature change.




Start the simulation, then click "Begin transfer of thermal energy from helium to the surroundings" to see what happens to particle motion when thermal energy transfers from the helium gas to the outside air.

Write a scientific explanation to tell Justin how the temperature of the helium gas in the balloon would change if the balloon was taken outside. Use what you observed in the simulation as evidence.

Sourced from Next Generation Science Assessment

| Culturally and Linguistically Responsive Instruction | | |
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| *Validate and Affirm* | *Build and Bridge* | *Linguistic Vocabulary Support* |

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| | During the phenomena talk about why looking at different scales is useful. Hot and cold tea, for example, look mostly similar at the macroscopic scale, but they feel very different to the touch. Ask students to think about why looking at the tea at a particle scale could be helpful to them in answering their questions.<br><br>In your experiences, what do the words heat and temperature mean? How are they similar, how are they different?<br><br>What experiences have you had with really high temperatures? | Why do you think it would be important for you and your community to understand how heat transfers?<br><br>Build a Driving Question Board where students can add their questions and re-address their learning through time. Revisit this board often to help students make sense of their science learning. | Throughout the standard, students will be asked to predict and describe changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed. Create the routine for physical science, to allow students to preview any learning material for unknown words. Provide the meaning with no judgment or reference to other learning material. **Best practice when this happens is for the teacher to keep a running record of the words and frequency.*<br><br>Build a driving question board where students can stick questions and re-address their learning over time. Revisit this board often to help students make sense of their science learning. Bring those questions to group discussion.<br><br>Encourage students to work with vocabulary in meaningful ways. As students engage in sensemaking, students discuss complex ideas with everyday vocabulary and use many different verbal and non-verbal strategies to community their ideas. A common practice is to create an interactive "word wall" with students, with all the terms they have used when thinking and talking about the phenomena over the course of the unit. Overtime, teachers support, encourage, and/or require students to use proper terms as they ask questions, design experiments, and argue with evidence. Some vocabulary to utilize: thermal energy, inert atoms, collide, particles, particle motion, pure substance (PS1-1 carbon dioxide, water, helium), temperature, solids, liquids, gases, phase change, pressure. |
| | **Planning for Multi-Layer System of Support (MLSS) & Universal Design Learning** | | |
| | ***Layer 1***<br>***Core Instruction + Universal*** | ***Layer 2***<br>***Core + Targeted*** | ***Layer 3***<br>***Core + Targeted + Intensive*** |
| | *Instructional/Academic Supports* | | |

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| | **Minimize threats and distractions:** During the phenomenon, or throughout instruction, encourage all students to share at least one idea with the class. If students are unwilling to share aloud, consider an exit ticket or have them whisper to you. Select a few responses to share and ask for permission before doing so. This minimizes student risk and increases engagement of students who are not normally heard from.<br><br>**Maximize transfer and generalization:** All learners need to be able to generalize and transfer their learning to new contexts. Students vary in the amount of scaffolding they need for memory and transfer in order to improve their ability to access their prior learning. Supports for generalization and transfer include visual imagery and type of graphic organizers for note taking. Consider using a sequencing graphic organizer throughout instruction for students to capture the stages of heating/melting by various substances (ice cube melting, wax, water heating, etc). Ideally, students should write a description of the various stages as well as draw a picture.<br><br>**Universal Design for Learning**<br>Representation<br>Engagement<br>Action and Expression<br>STEM Ready UDL Supports | **Maximize transfer and generalization:** Using the same sequencing graphic organizer as in Layer 1, some students may still struggle with accessing this learning. Provide some pre-completed templates with one or two of the stages filled in so students can recognize the patterns.<br><br>**Highlight patterns, critical features, big ideas, and relationships:** One of the big differences between experts and novices in any domain is the facility with which they distinguish what is critical from what is unimportant or irrelevant. Students will continue to need multiple examples and non-examples to emphasize particle motion and phase change with the addition or removal of heat. | Consider the misconceptions in content and skills needed within the PE and identify students for small group intervention.<br><br>**Guide information processing and visualization:** Successful transformation of information into usable knowledge often requires the application of mental strategies and skills for "processing" information. One suggested strategy is to give explicit prompts in a sequential process for students to have the opportunity to share their thinking.<br><br>Teacher provides various scenarios like hot air balloon, melting butter, ice melting, while students have a set of index cards. On the index cards should be words, images, and symbols to represent temperature increase, temperature decrease, particle motion, and the different states of matter (solid, liquid, gas).<br><br>Students should have all index cards (additionally it may be beneficial for students to create their own cards with the visual imagery). Teacher says substances or scenarios of thermal energy being added or removed. In response, students will lay down the index cards of their thinking of the various scenarios provided by the teacher. |
| | *Social Emotional Supports* | | |

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| | Integrate CASEL Playbook Strategies into your whole class routines or instruction. Some emphasized strategies/suggested activities are:<br><br>**Self/Social Awareness:** After introducing the phenomenon, utilize the Optimistic Closure-Human Bar Graph (p.39) for their current understanding of the phenomenon or questions. | Provide small-group support for students in need of focused skill instruction related to self-awareness, self-management, social awareness, relationship skills, and responsible decision making.<br><br>Increase positive reinforcement within the classroom for positive behavior. | Ensure that all learning environments allow students to thrive by considering the PBIS Sensory Tools.<br><br>Develop consistent Behavior Meetings to help build consistency and support for the students.<br><br>Additional student stakeholders may offer additional support through Counselor Referral or Collaboration with a student's physician or mental health provider. |
| | *Behavioral Supports* | | |
| | For all students, the use of Clear, consistent, and predictable consequences helps build a productive learning environment. | Ensure the use of a PBIS Behavior Contract during lab investigations and hands-on learning to ensure Layer 1 routines are supported.<br><br>With challenging academic learning, utilize PBIS Structured Breaks throughout the learning cycle to support the multi-sensory environment of phenomena-based science. | Utilize the PBIS Check In Check Out (CICO) to engage all student stakeholders in creating a consistent learning environment. |

**Cross-Curricular Connections**

| *ELA/Literacy* | *Mathematics* |
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| **RST.6-8.7** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-PS1-4) | **6.NS.C.5** Understand that positive and negative numbers are used together to describe quantities having opposite directions or values (e.g., temperature above/below zero, elevation above/below sea level, credits/debits, positive/negative electric charge); use positive and negative numbers to represent quantities in real-world contexts, explaining the meaning of 0 in each situation. (MS-PS1-4) |

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| | Continuing the Layer 1 consideration of using sequencing graphic organizers, provide students with a technical text overviewing a scenario of thermal energy being added or removed. Encourage students to next create a 'Comic Book' using a pre-selected number of boxes for the students to create a story of what is happening from the text. Be sure to include key target vocabulary by listing on the board or providing on the document. | Consider providing students a task such as: One morning the temperature is -28° in Anchorage, Alaska, and 65° in Santa Fe, New Mexico. How many degrees warmer was it in Santa Fe than in Anchorage on that morning?<br><br>The purpose of this task is for students to apply their knowledge of integers in a real-world context.<br><br>Adapted from Illustrative Mathematics It's Warmer in Miami |
| | *Career & Skill Connections* | |
| | Atmospheric science<br>Biology<br>Chemistry<br>Conservation science<br>Culinary | Mechanical engineering<br>Meteorology<br>Solar energy systems engineering |

| Grade | NGSS Discipline Overview |
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| **MS** | **Physical Science** |
| **Click to find the standards breakdown.** | **Teacher Background by Performance Expectation (PE)** |
| **PS1-5** | To make sense of a given phenomenon, students will need to develop a model in which they identify the relevant components for a given chemical reaction, including the types and number of molecules that make up the reactants and the types and number of molecules that make up the products.<br><br>In their model, students will need to be able to describe relationships between the components, including the fact that each molecule in each of the reactants is made up of the same type(s) and number of atoms, that when a chemical reaction occurs, the atoms that make up the molecules of reactants rearrange and form new molecules (i.e., products) that the number and types of atoms that make up the products are equal to the number and types of atoms that make up the reactants, and that each type of atom has a specific mass, which is the same for all atoms of that type.<br><br>Students will need to use the model to describe how the atoms that make up the reactants rearrange and come together in different arrangements to form the products of a reaction. Students will also need to use the model to provide a causal account that mass is conserved during chemical reactions because the number and types of atoms that are in the reactants equal the number and types of atoms that are in the products, and all atoms of the same type have the same mass regardless of the molecule in which they are found. |

| Standards Breakdown | | | | |
|---|---|---|---|---|
| MS | **Physical Science 1-5** | | | |
| **PS1-5** | *The performance expectation below was developed using the following elements from the NRC document, A Framework for K-12 Science Education* | | | |
| | **MS-PS1-5: Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved.**<br><br>**Clarification Statement:** Emphasis is on Law of Conservation of Matter and on physical models or drawings, including digital forms, that represent atoms.<br><br>**Assessment Boundary:** Assessment does not include the use of atomic masses, balancing symbolic equations, or intermolecular forces. | **SEP**<br><br>**Developing and Using Models**<br>Modeling in 6–8 builds on K–5 and progresses to developing, using and revising models to describe, test, and predict more abstract phenomena and design systems.<br>• Develop a model to describe unobservable mechanisms.<br><br>**Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena**<br>• Laws are regularities or mathematical descriptions of natural phenomena. | **DCI**<br><br>**PS1.B: Chemical Reactions**<br>• Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants.<br><br>• The total number of each type of atom is conserved, and thus the mass does not change. | **CCC**<br><br>**Energy and Matter**<br>• Matter is conserved because atoms are conserved in physical and chemical processes |
| | *These standards are not meant to be taught individually on their own, but bundled with other standards. Bundles are groups of standards arranged together to create endpoints for instruction and it helps students see connections between concepts and allow more efficient use of instructional time. Work with your local school, or district, on creating bundles for your middle school science courses or you can utilize resources and guidance from NMPED.* | | | |
| | **Common Misconceptions** | | | |
| | ● During a chemical reaction, atoms stay the same but rearrange to form new molecules.<br>● After a chemical reaction occurs, some of the atoms are connected to different atoms than they were in the starting molecules.<br>● When plants grow, they take in atoms from the environment that become part of the plant.<br>● The Law of Conservation of Mass does not apply to atoms.<br>● Matter is not created when living organisms grow. The matter added to their bodies comes from atoms that were outside the organism.<br>● Unaware of how elements can form other elements.<br>● All solutions are pure liquids.<br>● There is such a thing as an unbalanced chemical equation. | | | |

| New Mexico Relevant Phenomena | |
|---|---|
| *When available, you should use your locally selected or created high quality instructional materials. However, the following is an example phenomenon you can use if you don't have local high quality instructional materials available.* | |
| *How can we make something new that was not there before?* | *How can we explain what happens to wood from a campfire?* |

This HQIM phenomenon is also used in PS1-1 and provides an example of bundling standards for students to see connections between concepts.

When solid bath bombs are added to water, they start breaking apart, and gas bubbles appear on and around them for a few minutes, until no solid is left. We observe different bath bombs and what they do when added to water and then develop individual models and explanations to show what is happening at a scale smaller than we can see.

OpenSciEd 7.1: Chemical Reactions and Matter: [7.1 Chemical Reactions & Matter - Unit Download - OpenSciEd]

*Explain why the ingredients have the same mass as before and after the experiment reactions in a bag.*

This [video] shows a chemical reaction of sodium bicarbonate (baking soda), calcium chloride (road salt), and an indicator phenol red. The chemicals react to form calcium carbonate, sodium chloride, and carbon dioxide gas. This changes the pH inside the bag resulting in a color change in the phenol red. As much air as possible should be removed from the bag as possible to show the production of the gas. This could be used as an example of a chemical reaction that releases energy (exothermic). Since the bag is sealed it could be massed before and after to show the conservation of mass (atoms).

Camping is one of the most popular attractions to local residents and visitors. Encompassing six of the world's seven life zones, the state's landscapes offer a taste of nearly all climes. Open space, along with diverse wildlife and plant species are plentiful in this vast and sparsely populated state. Every year the Land of Enchantment attracts millions of visitors who seek out its scenic beauty and infinite varieties of outdoor recreation.Federal and state lands offer an abundance of public hiking trails and campgrounds, and several Native communities permit camping, hiking, hunting, and fishing.

[New Mexico Camping & Hiking | State Parks & Campgrounds]

Ask students if they have any experience camping for building fires with their families.

*How can one mineral change into another type of mineral completely naturally over time?*

Opportunity for teacher to demonstrate or have students complete a hands-on investigation by combining lemon juice/vinegar and baking soda inside a zip lock bag. Students can also learn more if they carefully measure and add the materials themselves in the bag and quickly seal it. Then time how fast the reaction takes place.

Sourced from Wonder of Science [Reaction in a Bag]

*Explain what are the reason/s why the burned wool is heavier than the unburned wool?*

This is an excellent phenomenon to discuss chemical reactions and the conservation of mass. Steel wool is burned leading to an increase in mass. When doing this in class, show the students the burning steel wool to begin with and have them predict the change in mass. Most students believe the mass will either increase or decrease. This phenomenon can be used at the beginning of a unit on chemical reactions and students can investigate their individual models. (e.g. mass comes from fire, oxygen, carbon, etc.)

Opportunity for a teacher-led demonstration phenomena for the teacher is to prepare fine steel wool without soap, scale, matches and aluminum container/bowl to demonstrate this in class.

Video Resources: [Burning Steel Wool — The Wonder of ScienceBurning steel wool]-

Show the video [Carlsbad Caverns National Park in New Mexico: Exploring the Big Room & Natural Entrance] to engage students in a video field trip

Teachers can ask students if they have ever been hiking in New Mexico and found crystals on the trail, or seen layers of white crystals in rocks as they are walking. Ask them if they've ever wondered how those shiny white crystals of gypsum formed.

The chemical reaction involved in the formation of gypsum (calcium sulfate dihydrate) in New Mexico caves can be represented by the following equation:

Calcium Carbonate (in limestone) + Sulfuric Acid → Calcium Sulfate Dihydrate (Gypsum) + Carbon Dioxide + Water

$CaCO3 + H2SO4 \rightarrow CaSO4 \cdot 2H2O + CO2 + H2O$

This reaction occurs when calcium carbonate, which is abundant in limestone rock formations, reacts with sulfuric acid. The sulfuric acid is often derived from hydrogen sulfide gas released by decaying organic matter in the cave environment.

The reaction results in the formation of gypsum, along with the release of carbon dioxide and water. This chemical reaction illustrates the conservation of matter principle, as the total number of atoms remains constant throughout the reaction.

Teachers can ask students if they have ever been hiking in New Mexico and found crystals on the trail, or seen layers of white crystals in rocks as they are walking. Ask them if they've ever wondered how those shiny white crystals of gypsum formed. Provide students a copy of excerpts from [Origin of gypsum deposits in Carlsbad Caverns, New Mexico] and have them generate some questions or wonderings for a class Driving Question Board.

**Classroom Assessment Items**

*When available, you should use your locally selected or created high quality instructional materials. However, the following is an example phenomenon you can use if you don't have local high quality instructional materials available.*

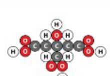
<u>Explaining New Aspects of the Anchoring Phenomena Bath Bombs</u>

A group of students in another class investigated why bath bombs behave the way they do. They added baking soda to citric acid and water and collected evidence that a chemical reaction between these substances produced carbon dioxide gas from a chemical reaction. But this group of students wondered if the chemical reaction in the container produced other substances too. They wanted to test the liquid left in the container to figure this out.

Q1) To do this, they boiled the liquid left over in the container and captured the gas from this. As the gas they captured cooled back down, it became a clear liquid. They measured the density of the liquid they collected and determined that it is the same as water. They were surprised, however, to find that they had 4.3 grams more water now than they had at the start (before mixing everything together).

Explain how a chemical reaction between molecules of baking soda and molecules of citric acid could also have produced some new water molecules? Use the models below to support your explanation.

| Atom symbol | Atom name |
|---|---|
| H | Hydrogen |
| C | Carbon |
| Na | Sodium |
| O | Oxygen |
| N | Nitrogen |

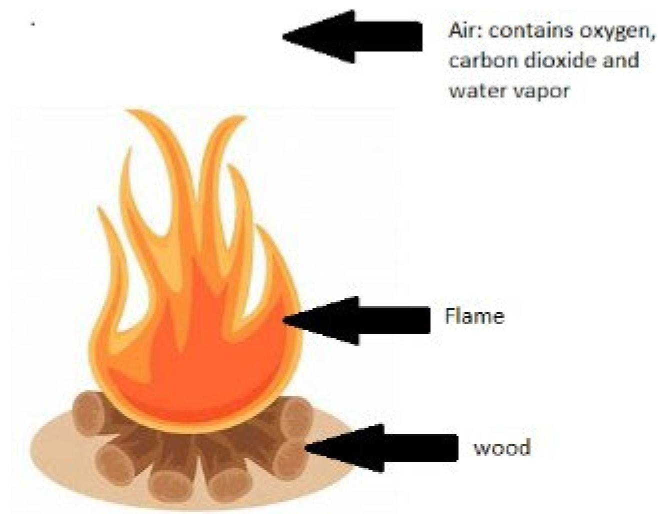
| Substance | Molecular formula | 2D model |
|---|---|---|
| Water | $H_2O$ |  |
| Baking soda | $NaHCO_3$ |  |
| Citric acid | $C_6H_8O_7$ |  |

Q2) After boiling off the water, there was a whitish powder left in the bottom of the container. One group member claimed this is either citric acid or baking soda. Another group member disagreed and claimed that this might be a third new substance

<u>Campfire Wood</u>

A few students were building a campfire with one of their parents. One of the students noticed that after the fire died down, the wood was much smaller than it had been from the start. Curious, they wondered where the wood had gone. Play this [video](#) to engage students with the sounds of a fire.

A group of students are at summer camp. To start a fire, they need wood ($C_6H_{10}O_5$), oxygen ($O_2$) and energy. As the fire burns, it produces carbon dioxide ($CO_2$) and water ($H_2O$). Carbon dioxide and water are invisible, so the students cannot see them come off the fire.




Chemical reaction of burning wood:
$C_6H_{10}O_5$ (wood) + $6O_2$ (oxygen) + HEAT → $6CO_2$ (carbon dioxide) + $5H_2O$ (water vapor)

Your Task
In the questions that follow, you will be using a model of wood in a campfire to explain whether or not matter is conserved.

Question 1: The students remember learning about reactions in science class. a student asks, "When we light a fire, what are the products and what are the reactants?"

$C_6H_{10}O_5$ (wood) + $6O_2$ (oxygen) + HEAT → $6CO_2$ (carbon dioxide) + $5H_2O$ (water vapor)

Using the chemical equation above, help the student

| | | |
|---|---|---|
| | that was produced in the chemical reaction. They tested the properties of the unknown powder left over and compared it to samples of citric acid and baking soda to try to determine which claim is correct.<br><br>Additional questions can be found on the original source from [7.1 Chemical Reactions & Matter - Unit Download - OpenSciEd]() | identify each.<br><br>Material \| Wood \| Oxygen \| Carbon Dioxide \| Water Vapor<br>Mass (kg) \| 2.32 Kg \| 2.75 Kg \| 3.78 Kg \| 1.29 Kg<br><br>Question 2: Before the students light the fire, they draw models of the molecules. Which model do you agree with?<br><br>Name of molecules in **products** \| Name of molecules in **reactants** |

Battery Under Water

Rosy put a battery in a beaker of tap water. She observed gas bubbles coming from the positive and negative ends of the battery, as shown in the video below.

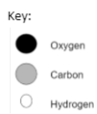

[a-battery-in-a-beaker-of-tap-water2.mp4]

She tested the bubbles and found that some of the bubbles were made of hydrogen gas and some were made of oxygen gas.

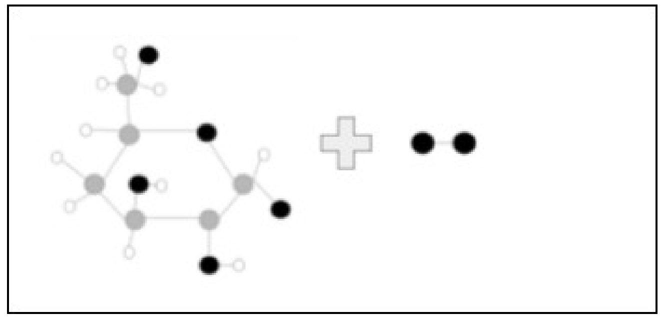
Draw a model that shows the chemical reaction of water changing into hydrogen and oxygen gas. Include the following descriptions for your model: 1) what happens during the reaction to the atoms of the water molecules; and 2) how your model explains why mass is conserved during this reaction.


Sourced from Wonder of Science MS-PS1-5 Assessment - Battery Under Water

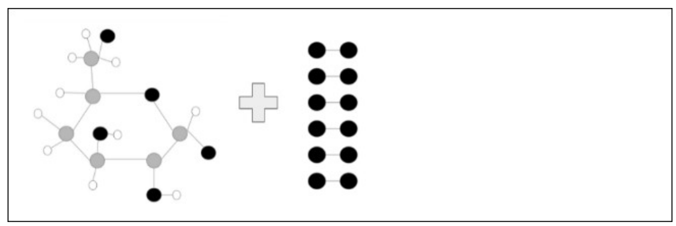
Reaction:
$C_6H_{10}O_5$ (wood) + $6O_2$ (oxygen) + HEAT → $6CO_2$ (carbon dioxide) + $5H_2O$ (water vapor)



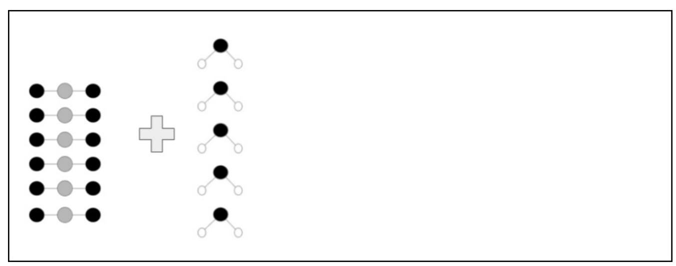

A. Student A



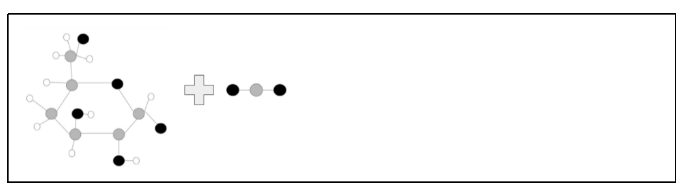
B. Student B



C. Student C



D. Student D



Additional questions can be found on the original source from SEEd Campfire Wood SEEd 8.1.6 Formative Assessment

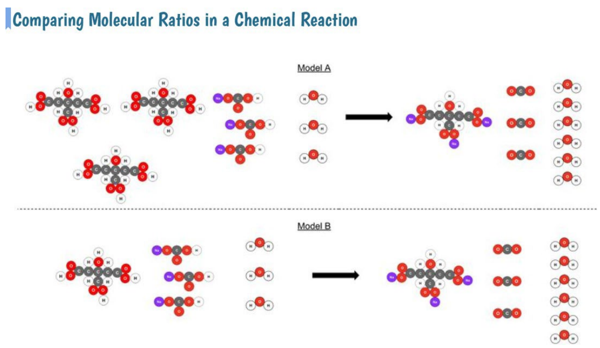
| Culturally and Linguistically Responsive Instruction | | |
|---|---|---|
| *Validate and Affirm* | *Build and Bridge* | *Linguistic Vocabulary Support* |

| | | | |
|---|---|---|---|
| | In your experience, how are interactions and reactions similar to and different from each other?<br><br>How does adding the word chemical change these meanings for you? | Why do you think it would be important for you and your community to understand the Law of Conservation of Mass?<br><br>Build a Driving Question Board where students can add their questions and re-address their learning through time. Revisit this board often to help students make sense of their science learning. | Throughout instruction, students will be asked to describe how the total number of atoms does not change in a chemical reaction. Create the routine for physical science, to allow students to preview any learning material for unknown words. Provide the meaning with no judgment or reference to other learning material. ******Best practice when this happens is for the teacher to keep a running record of the words and frequency.*<br><br>Encourage students to work with vocabulary in meaningful ways. As students engage in sensemaking, students discuss complex ideas with everyday vocabulary and use many different verbal and non-verbal strategies to community their ideas. A common practice is to create an interactive "word wall" with students, with all the terms they have used when thinking and talking about the phenomena over the course of the unit. Overtime, teachers support, encourage, and/or require students to use proper terms as they ask questions, design experiments, and argue with evidence. Some vocabulary to utilize: atoms, molecules, mass, chemical reaction, products, reactants, symbols, chemical formula, Law of Conservation of Mass |
| | **Planning for Multi-Layer System of Support (MLSS) & Universal Design Learning** | | |
| | ***Layer 1***<br>***Core Instruction + Universal*** | ***Layer 2***<br>***Core + Targeted*** | ***Layer 3***<br>***Core + Targeted + Intensive*** |
| | *Instructional/Academic Supports* | | |

| | | | |
|---|---|---|---|
| | **Guide information processing and visualization:** Students will need multiple strategies and multiple entry points within the lesson to process and transfer their learning.<br><br>Create a graphic organizer with the chemical equations for photosynthesis. Have the organizer separated into the equation format for students to take notes through the introduction of chemical formulas, reactants, and products. It may be beneficial to provide a checklist to guide student understanding of what to look for during instruction. | **Guide information processing and visualization:** Provide various interactive models and hands-on investigations for students to show conservation of mass and practice applying balanced equations. EX: Try a variation of one of the phenomena suggestions by collecting 20 oz plastic bottles and mixing the vinegar and baking soda within there with balloons. Students will see the gas build up in the balloon but it will be sealed for them to measure the before and after mass. | Consider the misconceptions in content and skills needed within the PE and identify students for small group intervention.<br><br>Continue using multiple practices and entry points for smaller groups that are different from previous models.<br><br>Allow students multiple opportunities to share their thinking visually and orally through scaffolded questioning and student created models.<br><br>Provide immediate feedback as students respond to prompts through modeling, drawings, or questioning. |

| | | | |
|---|---|---|---|
| | Consistently reinforce the idea that matter is conserved because atoms are conserved in chemical processes.<br><br>**Illustrate through multiple media:** Conceptualizing the unseen can be difficult for students, so using paper representations of molecular structures can help students be able to picture what is happening to the molecules during different chemical processes. It is recommended you have many of the molecule representations from paper cutouts, styrofoam balls, or actual molecule manipulatives so students can consistently reference.<br><br>**Universal Design for Learning**<br>Representation<br>Engagement<br>Action and Expression<br>STEM Ready UDL Supports | | |
| | *Social Emotional Supports* | | |

| | | | |
|---|---|---|---|
| | Integrate CASEL Playbook Strategies into your whole class routines or instruction. Some emphasized strategies/suggested activities are:<br><br>**Responsible Decision-Making, Relationship Skills, and Social Awareness:** While conducting investigations, utilize the Engaging with Data (p.24) protocol as a structured way to engage with data, with a focus on reflecting on implications and developing next steps.<br><br>Students will go through four main steps: predictions, descriptions, interpretations, and implications. | Integrate CASEL Playbook Strategies into your whole class routines or instruction. Some emphasized strategies/suggested activities are:<br><br>**Self-Awareness, Self-Management, and Relationship Skills:** Throughout instruction, consider Team Quiz Hustle (p. 35). Utilize this within instruction as a brain break that reinforces the content. Students combine reviewing academic material with movement and teamwork.<br><br>Provide small-group support for students in need of focused skill instruction related to self-awareness, self-management, social awareness, relationship skills, and responsible decision making.<br><br>Increase positive reinforcement within the classroom for positive behavior. | Use the multi-layer PBIS Teach Relaxation Techniques to students that may be overwhelmed with persevering through this concept.<br><br>Ensure that all learning environments allow students to thrive by considering the PBIS Sensory Tools.<br><br>Develop consistent Behavior Meetings to help build consistency and support for the students.<br><br>Additional student stakeholders may offer additional support through Counselor Referral or Collaboration with a student's physician or mental health provider. |
| | *Behavioral Supports* | | |
| | For all students, the use of Clear, consistent, and predictable consequences helps build a productive learning environment. | Ensure the use of a PBIS Behavior Contract during lab investigations and hands-on learning to ensure Layer 1 routines are supported.<br><br>With challenging academic learning, utilize PBIS Structured Breaks throughout the learning cycle to support the multi-sensory environment of phenomena-based science. | Utilize the PBIS Check In Check Out (CICO) to engage all student stakeholders in creating a consistent learning environment. |
| | **Cross-Curricular Connections** | | |
| | *ELA/Literacy* | *Mathematics* | |

| | |
|---|---|
| **RST.6-8.7** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-PS1-5) | **MP.2** Reason abstractly and quantitatively. (MS-PS1-5)<br><br>**MP.4** Model with mathematics. (MS-PS1-5)<br><br>**6.RP.A.3** Use ratio and rate reasoning to solve real-world and mathematical problems. (MS-PS1-5) |
| Consider providing students a visual of molecules in a chemical reaction and asking them to apply technical language and process in what is occurring within the diagram.<br><br><br><br><br>Sourced from Open Sci Ed Lesson 7 [7.1 Lesson 12 Handout Comparing Molecular Ratios] | Conservation of mass from chemical equations is an abstract concept for students to grasp. Use the PhET [Reactants, Products, and Leftovers] simulation for students to explore. Have students predict the products and leftovers after reaction based on the quantities of reactants and ratios of molecules in the balanced chemical equation.<br><br>Students should explore and be able to explain that atoms are conserved during a chemical reaction. |

| *Career & Skill Connections* | |
|---|---|
| Atmospheric science<br>Chemistry<br>Conservation science | Meteorology<br>Solar energy systems engineering |

| Grade | NGSS Discipline Overview |
|---|---|
| MS | Physical Science |
| Click to find the standards breakdown. | **Teacher Background by Performance Expectation (PE)** |
| **PS1-6** | Students will be given a problem to solve that requires either heating or cooling, and then design and construct a solution (i.e., a device). In their designs, students identify the components within the system related to the design solution, including the components within the system to or from which energy will be transferred to solve the problem, and the chemical reaction(s) and the substances that will be used to either release or absorb thermal energy via the device. Students should also describe how the transfer of thermal energy between the device and other components within the system will be tracked and used to solve the given problem.<br><br>Students will need to describe the given criteria, including features of the given problem that are to be solved by the device, the absorption or release of thermal energy by the device via a chemical reaction. Students will also need to describe the given constraints, which may include the amount and cost of materials, safety, and the amount of time during which the device must function.<br><br>Students will need to test the solution for its ability to solve the problem via the release or absorption of thermal energy to or from the system. Students will then use the results of their tests to systematically determine how well the design solution meets the criteria and constraints, and which characteristics of the design solution performed the best.<br><br>Finally, students will need to modify the design of the device based on the results of iterative testing, and improve the design relative to the criteria and constraints. |

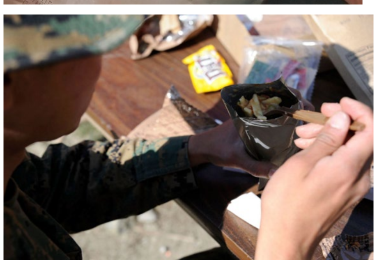
<table>
<tr><th colspan="5">Standards Breakdown</th></tr>
<tr><td>MS</td><td colspan="4"><u>Physical Science 1.6</u></td></tr>
<tr><td rowspan="4">PS1-6</td><td colspan="4">The performance expectation below was developed using the following elements from the NRC document, A Framework for K-12 Science Education</td></tr>
<tr><td rowspan="2">MS-PS1-6: Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.<br><br>Clarification Statement: Emphasis is on the design, controlling the transfer of energy to the environment, and modification of a device using factors such as type and concentration of a substance. Examples of designs could involve chemical reactions such as dissolving ammonium chloride or calcium chloride.<br><br>Assessment Boundary: Assessment is limited to the criteria of amount, time, and temperature of substance in testing the device.</td><td>SEP</td><td>DCI</td><td>CCC</td></tr>
<tr><td>Constructing Explanations and Designing Solutions<br>Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific knowledge, principles, and theories.<br>• Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints.</td><td>PS1.B: Chemical Reactions<br>• Some chemical reactions release energy, others store energy.<br><br>ETS1.B: Developing Possible Solutions<br>• A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (secondary)<br><br>ETS1.C: Optimizing the Design Solution<br>• Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process - that is, some of the characteristics may be incorporated into the new design. (secondary)<br>• The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. (secondary)</td><td>Energy and Matter<br>• The transfer of energy can be tracked as energy flows through a designed or natural system.</td></tr>
<tr><td colspan="4">These standards are not meant to be taught individually on their own, but bundled with other standards. Bundles are groups of standards arranged together to create endpoints for instruction and it helps students see connections between concepts and allow more efficient use of instructional time. Work with your local school, or district, on creating bundles for your middle school science courses or you can utilize resources and guidance from <u>NMPED</u>.</td></tr>
<tr><td></td><td colspan="4">Common Misconceptions</td></tr>
</table>

- Temperature is a property of a particular material or object——metal is naturally cooler than plastic.
- The temperature of an object depends on its size.
- Heat and cold are different, rather than being opposite ends of a continuum.
- Boiling is the maximum temperature a substance can reach.
- Ice cannot change temperature.

| New Mexico Relevant Phenomena | |
|---|---|
| *When available, you should use your locally selected or created high quality instructional materials. However, the following is an example phenomenon you can use if you don't have local high quality instructional materials available.* | |
| *How can we use chemical reactions to design a solution to a problem?* | *How does the earth release heat through a chemical process?* |

This HQIM phenomenon is also used in ETS1-3 and provides an example of bundling standards for students to see connections between concepts.

Show students images of MREs and discuss how in times of natural disasters from hazards like flooding, severe storms, or power outages, MREs are available to provide food. MREs include something called a 'flameless heat' that is able to warm food without using electricity, gas, or fire. What do you think is inside the MRE package? How do you think the flameless heater works?
*Note: If possible, it would be beneficial to get a MRE to share with the class, however, if it is not, you can utilize the photos as well as this video* or this site for more information *Meals Ready to Eat Natick Labs: The Science Behind Military Food*



Hot springs in New Mexico release thermal energy primarily through the process of geothermal heating, which involves the transfer of heat from the Earth's interior to the surface. The thermal energy originates from the Earth's mantle and crust, where it is generated by the decay of radioactive isotopes and residual heat from the planet's formation.

Show the video about Yellowstone's chemical hot springs (Acid Pools of Death) and photos of some of New Mexico's hot springs. Ask students what they notice about the Yellowstone hot springs. Do they look like the hot springs we have in New Mexico? What evidence do they see of chemical reactions taking place? *Note: The video is about Yellowstone, but the same principles apply to New Mexico hot springs.*

Now ask students if they have any wonders: Is the overall geology similar in Yellowstone to the mountains here in New Mexico? Both were formed from volcanic activity, which set of mountains seems to be more volcanically active now? How might this affect the chemistry of the hot pools differently in the different locations?

The role of chemical processes in the release of thermal energy in hot springs is significant. As water percolates through underground rock formations, it comes into

Students are introduced to the anchoring phenomenon—a flameless heater in a Meal, Ready-to-Eat (MRE) that provides hot food to people by just adding water. In the first lesson set, students explore the inside of an MRE flameless heater, then do investigations to collect evidence to support the idea that this heater and another type of flameless heater (a single-use hand warmer) are undergoing chemical reactions as they get warm.

Sourced from Open Sci Ed [7.2 Chemical Reactions & Energy]

*How are reusable heat packs design and how do they work?*

This phenomenon uses a supersaturated solution of sodium acetate. Clicking the metal disc releases a small number of crystals of sodium acetate which act as nucleation sites for the crystallization of the sodium acetate into a hydrated salt. Energy is released from the crystal lattice.

The heating pack can be placed in boiling water and the sodium acetate can be dissolved again. This phenomenon shows how bond energy can be released. It also shows the importance of chemical engineering and could lead to a section where students design a device (or application) of their own.

Also there is an added opportunity for learning if students will closely observe how fast this chemical reaction takes place specially if they do this in person. Various sizes of heat packs would be advisable to observe if size has an effect on the spread of chemical reaction.

Sourced from Wonder of Science [Reusable Heat Packs]

contact with minerals and gasses present in the Earth's crust. These interactions lead to chemical reactions that can contribute to the heating of the water.

One key chemical process involved in hot spring formation is the dissolution of minerals in the rock by acidic fluids. As water interacts with certain minerals, such as sulfides or carbonates, it can undergo reactions that release heat energy. For example, the reaction between sulfuric acid (derived from hydrogen sulfide gas) and carbonate minerals in limestone can produce calcium sulfate (gypsum) and carbon dioxide, releasing heat in the process.

Additionally, the presence of gases such as carbon dioxide and hydrogen sulfide in hot spring waters can contribute to thermal energy release. These gases, which are often brought to the surface through volcanic activity or hydrothermal vents, can dissolve in groundwater and react with surrounding minerals, releasing heat as a byproduct.

Overall, the combination of geothermal heating and chemical processes, including mineral dissolution and gas-water interactions, leads to the release of thermal energy in New Mexico's hot springs. These processes contribute to the warm temperatures and unique geological features observed in hot spring environments.

## Classroom Assessment Items

*When available, you should use your locally selected or created high quality instructional materials. However, the following is an example phenomenon you can use if you don't have local high quality instructional materials available.*

Help Your Teacher

One of your teachers has a problem. You've noticed that anytime their coffee gets cold (below 130 degrees fahrenheit) during the first period, they stop drinking it and become very cranky. You're tasked to design something that can warm up your teacher's coffee using chemical reactions before it gets too cold! Whatever you build needs to be safe enough to work inside the classroom and it needs to fit on the teacher's desk.

1. Draw and label a model of a device that uses a chemical reaction to keep your teacher's coffee hot.
2. Explain how your solution works and how it uses a chemical reaction to keep your teacher's coffee hot.
3. What would be the best way to test how well a solution to this problem works?

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Sea Turtle Assessment

Sea Turtle Population in Danger?

Name: ______________________ Date: ______________

### Form A: Sea Turtle Assessment

Sea Turtle Population in Danger?

In 2018, there were a lot of news stories with headlines like this: "The sea turtle population in Australia is mostly females" and "Most of the new sea turtles born are female."

**The problem:** In 2018, scientists in Australia conducted a study to understand the proportion of male to female sea turtles near the Great Barrier Reef. They expected to find slightly more females because of the rising temperatures on this warm beach. They were surprised to find that, of a population of 200,000 sea turtles, 99.1% of the youngest ones were female, 99.8% of the teenage turtles were female, and 86.8% of the whole population was female. Sea turtles' sex is determined by the temperature of the egg while it is developing in the sand. This table shows the temperatures at which sea turtles hatch into males or females.

| Temperature | Sea turtles that hatch |
|---|---|
| 28°C (82°F) or below | Mostly males |
| Between 28°C (82°F) and 31°C (88°F) | Half male and half female |
| 31°C (88°F) or above | Mostly females |

With more and more female sea turtles, the populations of sea turtles around the world are in danger because both male and female sea turtles are needed to survive and reproduce.

**A solution?** Sea turtle conservation efforts are trying many different approaches to protect the sea turtle population. One idea is to move the eggs to an environment in which they can be kept at a controlled temperature. However, the eggs still need to be moved safely. In order to move sea turtle eggs safely, consider the following:

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Geothermal Energy

New Mexico is unique amongst states in that the state has several low-temperature (100-190°F) geothermal systems. A few hot springs in the Jemez Mountains are associated with cooling magma beneath the southwest margin of the Valles Caldera. Most of the hot springs in our state lie in or near the Rio Grande rift. Water falling as precipitation on the mountain ranges bordering the rift percolates to depths of 3-5 km and is heated by elevated rift-related heat flow. The heated fluids are then discharged as springs in the vicinity of rift-related faults or at intersections of multiple generations of geologic structures.

Commercial uses of geothermal waters in New Mexico include heating of buildings and greenhouses and aquaculture (fish farms). Spas and bathhouses are economically important tourist destinations in Truth or Consequences and at Ojo Caliente.

Reading Excerpt: Geothermal Greenhouse Heating at Radium Springs, New Mexico

How does the Masson Radium Springs geothermal greenhouse heating work? It is very simple. A geothermal well, a heat exchanger, an insulated hot water storage tank, and an injection well replace a fossil fuel boiler and a natural gas fuel supply. The hot water circulation system inside the greenhouse remains the same, although the size may vary depending on the hot water circulation temperature. Water that is 199°F is pumped from an 800-foot-deep geothermal well. The water is piped to a heat exchanger where the heat in salty geothermal water is transferred to fresh water. Hot 190°F freshwater is then pumped into an insulated, 187,000-gallon storage tank. The geothermal water with heat removed is then injected back into the reservoir to be reheated by hot rock, using a different well some distance from the production well. Hot fresh water at 180°F is pumped out of the storage tank and circulated through the greenhouse for heating, then returned to the heat exchanger to be reheated, starting another heating cycle through the greenhouse. All of this is possible with the heat of the earth, geothermal!

**Criteria**

- Sea turtle eggs must not rotate or change orientation from how they were first laid in the ground.
- In a natural environment, sea turtle eggs are heated from above as the Sun warms the sand on top of the eggs.
- Sea turtle eggs need humidity to grow, ideally between 80% and 90% relative humidity.
- A temperature of 28°C (82°F) or slightly lower is needed to help produce more male turtles.
- It takes about 10 minutes to move the eggs, so a heater must maintain the desired temperature for 10 minutes.

**Constraints**

- There is no access to a power source during transportation.

**Your task:** Evaluate and select the best possible design for a sea turtle egg incubator (a device that keeps objects warm) that can be used when the sea turtle eggs are moved to a more-permanent location.

**Part 1. Evaluate an Existing Incubator: Incubator A**

This is an existing egg incubator available for purchase online. Will it work to move the sea turtle eggs? Review the advertised characteristics of this incubator below:

- Incubation temperature is adjustable.
- Heating element is above the eggs.
- Eggs are rotated on rotating disks.
- Humidity can be set for up to 85% relative humidity.
- Power supply is from a cord to an outlet.
- It holds up to 7 eggs.
- The cost is $200.

**1a.** Complete the "1a. Optimal solution" row in the *Design Testing Matrix for Sea Turtle Assessment* to show the ideal incubator characteristics using the information shown in the list provided above of criteria and constraints for moving sea turtle eggs safely.

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**1b.** Incubator A was tested against the criteria and constraints, and the results of those tests are shown in the Design Testing Matrix.

Use the Design Testing Matrix to write an argument below that states whether incubator A will be sufficient to incubate sea turtle eggs effectively during relocation. Consider the criteria and constraints presented in the Design Testing Matrix and the advertised performance of incubator A in your argument.

Sourced from Open Sci Ed Lesson 10 [7.2 Lesson 10 Assessment Form A Sea]

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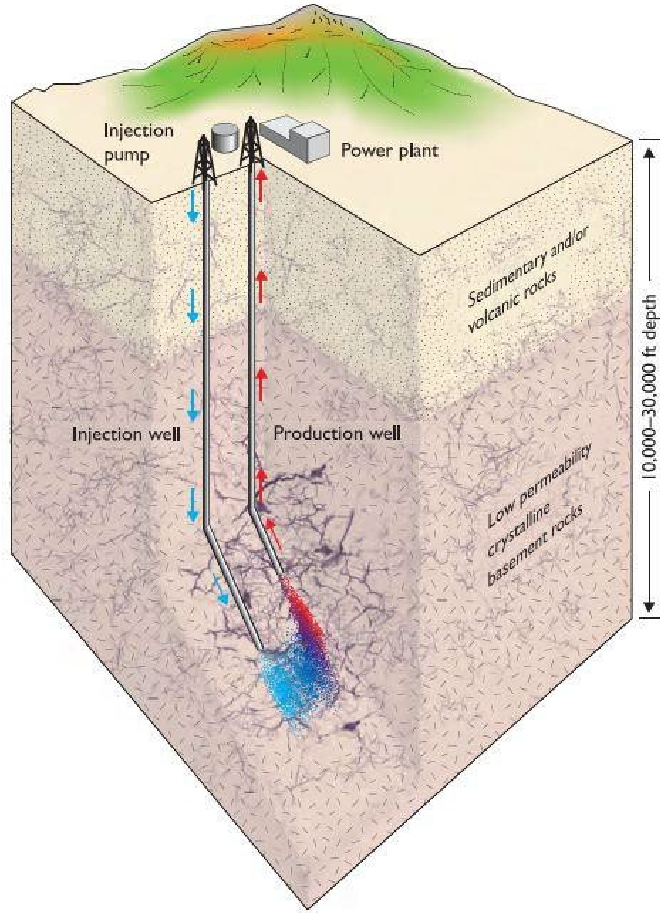
Creating a Better Hydro Flask/Water Bottle




Block diagram of an enhanced geothermal system. The blue represents cold water, the purple is warm water, and the red is heated water.

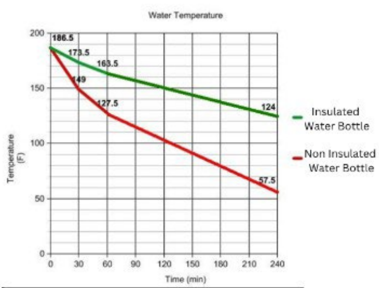
**Stimulus:** Creating A Better Hydroflask/Waterbottle

Phase Changes PhET Simulation
[https://phet.colorado.edu/sims/html/states-of-matter-basics/latest/states-of-matter-basics_en.html](https://phet.colorado.edu/sims/html/states-of-matter-basics/latest/states-of-matter-basics_en.html)

non insulated water bottle | insulated water bottle

Water bottles are sold in both insulated and non insulated styles. Insulated water bottles can maintain even temperatures for longer periods of time.

Graph 1: Water Temperature inside two different water bottles.




**Your Task**

In the questions that follow, you will compare and identify the best characteristics of competing devices, based on data analysis, and modify them to improve the device to better meet the criteria for success.

**Question 1**
Item: Using the PhET simulation, what changes are seen that indicate a change of phase? (Select all that apply.)

a. Particles of matter spread further apart indicating that the molecules have changed from a solid to a liquid.
b. Particles of matter gather closer together indicating that a gas has changed into a liquid.
c. Particles of matters are moving indicating evaporation.
d. Temperature rising and falling.

**Question 2**
Using Graph 1: Water Temperature inside two different water bottles, what happens to the temperature inside an insulated water bottle?

a. The temperature inside the non insulated water bottle decreased more than inside the insulated water bottle.
b. The temperature inside the non insulated water bottle increased more than inside the insulated water bottle.
c. The temperature inside the non insulated water bottle stayed the same as inside the insulated water bottle.

**Question 3**

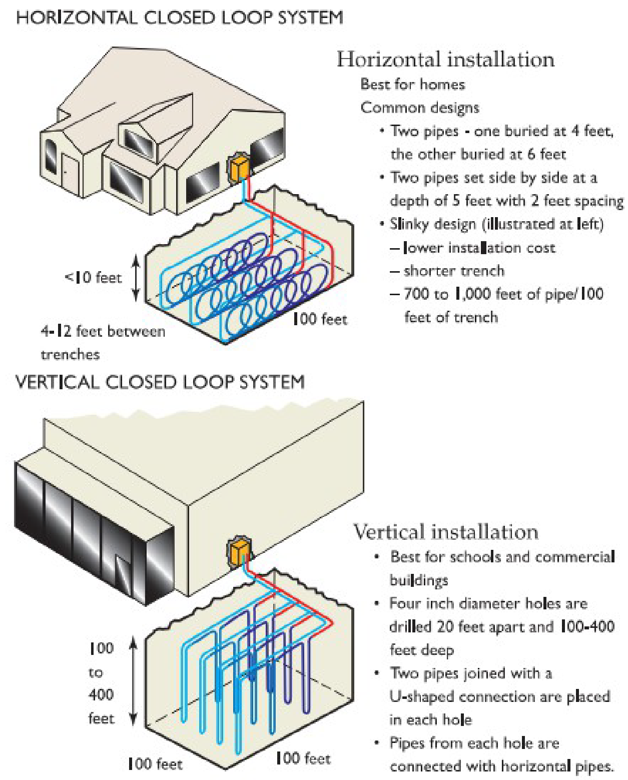
Draw and label a model for a water bottle that can effectively keep ice cold, include arrows indicating how thermal energy is conserved

**Question 4**

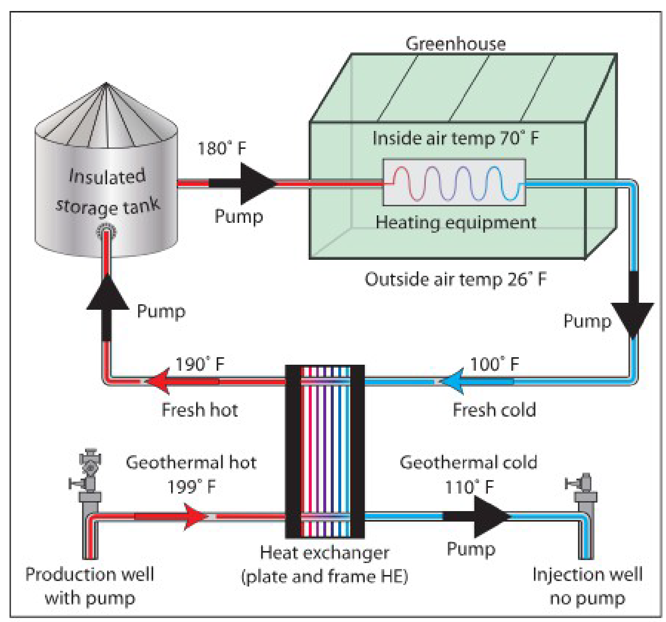
Which components are the most important to include in your design when trying to conserve heat or conserve cold?

Use the following words in your explanation: Thermal Energy, Conservation, Heat, Cold, temperature, particles of matter

Sourced from SEED [Water Bottle Design SEEd 8.1.7 Formative Assessment]()




Schematic diagrams of ground-source heat pump systems. The blue represents cold water, the purple is warm water, and the red is heated water. Modified from: **http://www.energysavers.gov/your_home/space_heating_cooling/index.cfm/mytopic=12640**




Schematic diagram of a geothermal heat exchange system for the Masson Radium Springs Farm greenhouse, New Mexico.

Task: Use the reading excerpt above and the previous figures to compare and identify the best characteristics of current geothermal technologies and applications in New Mexico

| | | |
|---|---|---|
| | | Question 1: Using the PhET simulation, what changes are seen that indicate a change of phase? (Select all that apply.)<br>A. Particles of matter spread further apart indicating that the molecules have changed from a solid to a liquid.<br>B. Particles of matter gather closer together indicating that a gas has changed into a liquid.<br>C. Particles of matters are moving indicating evaporation.<br>D. Temperature rising and falling.<br><br>Question 2: Why is it necessary to have an understanding of phase changes in matter and thermal energy?<br><br>Question 3: Imagine that someone wants to use geothermal systems in building their new house but they live in an area where no one has geothermal systems. What are some considerations you might share with them to make sure they understand geothermal energy and how it works?<br><br>Question 4: Which components are the most important when designing a geothermal system?<br><br>Adapted from Lite Geology Fall 2010 Issue 28 and Geothermal Resources in New Mexico and from SEED Water Bottle Design SEEd 8.1.7 Formative Assessment |

| Culturally and Linguistically Responsive Instruction | | |
|---|---|---|
| *Validate and Affirm* | *Build and Bridge* | *Linguistic Vocabulary Support* |

| | | | |
|---|---|---|---|
| | What experiences have you or your family had with having to fix a problem with only what you had on hand?<br><br>When you are confronted with a new problem, how do you go about determining a solution? | Why might it be important for your community to have engineers and repair persons?<br><br>Build a Driving Question Board where students can add their questions and re-address their learning through time. Revisit this board often to help students make sense of their science learning. | Throughout instruction, create the routine for physical science, to allow students to preview any learning material for unknown words. Provide the meaning with no judgment or reference to other learning material.<br>**Best practice when this happens is for the teacher to keep a running record of the words and frequency.*<br><br>Encourage students to work with vocabulary in meaningful ways. As students engage in sensemaking, students discuss complex ideas with everyday vocabulary and use many different verbal and non-verbal strategies to community their ideas. A common practice is to create an interactive "word wall" with students, with all the terms they have used when thinking and talking about the phenomena over the course of the unit. Overtime, teachers support, encourage, and/or require students to use proper terms as they ask questions, design experiments, and argue with evidence. Some vocabulary to utilize: chemical reaction, dissolving a substance, absorption, transfer of energy, concentration of a substance, thermal energy, exothermic reaction, endothermic reaction, design solution, energy, criteria, and constraints |

| | **Planning for Multi-Layer System of Support (MLSS) & Universal Design Learning** | | |
|---|---|---|---|
| | ***Layer 1***<br>***Core Instruction + Universal*** | ***Layer 2***<br>***Core + Targeted*** | ***Layer 3***<br>***Core + Targeted + Intensive*** |
| | *Instructional/Academic Supports* | | |

| | | | |
|---|---|---|---|
| | **Foster collaboration and community:** In the 21st century, all learners must be able to communicate and collaborate effectively within a community of learners. This standard supports various ways for students to engage in collaboration:<br>1. Create cooperative learning groups with clear goals, roles, and responsibilities<br>2. Create school-wide programs of positive behavior support with differentiated objectives and supports<br>3. Provide prompts that guide learners in when and how to ask peers and/or teachers for help<br>4. Encourage and support opportunities for peer interactions and supports (e.g., peer-tutors)<br>5. Construct communities of learners engaged in common interests or activities<br>6. Create expectations for group work (e.g., rubrics, norms, etc.)<br><br>**Facilitate managing information and resources:** Given a problem to solve that requires either heating or cooling, students design and construct a solution (i.e., a device). Provide a graphic organizer showing the | Students may need support with the graphical representation of their findings, but also may need support with the development of the investigation plan. One way to support this learning could be purposeful small groupings, and opportunities for Q&A check-ins with the teacher.<br><br>**Facilitate managing information and resources:** Students will also need to describe how the transfer of thermal energy between the device and other components within the system will be tracked and used to solve the given problem and the features of the given problem that are to be solved by this device through the absorption or release of thermal energy by the device via the chemical reaction.<br><br>Provide a graphic organizer and embed prompts for categorizing and systematizing this information. | Be intentional in the collaborative groupings selected and consider intentional student pairings.<br><br>Additionally, provide graphic organizers for students to organize design thinking processes and their learning from testing since this standard focuses on applying knowledge to a design solution.<br>Some students may need further assistance on analyzing, interpreting data, and identifying strengths and weaknesses in the design. |

| | | | |
|---|---|---|---|
| | engineering design process to help guide students through the design process as a way to organize their information and provide checklists for where they are in the design process.<br><br>**Universal Design for Learning**<br>Representation<br>Engagement<br>Action and Expression<br>STEM Ready UDL Supports | | |
| | *Social Emotional Supports* | | |
| | Integrate CASEL Playbook Strategies into your whole class routines or instruction. Some emphasized strategies/suggested activities are:<br><br>One of the phenomena is based on Meals, Ready-to-Eat, which include a flameless heater because it can be comforting to have a warm meal, especially in the types of situations where MREs are often used (see Spence [2017] and Lawrence and Bargh [2008]). However, for students who do not have regular access to enough food, designing around how best to heat food might be especially difficult. Before beginning this unit, confirm what support your school has in place for students who deal with food insecurity and be aware of this for instruction. | Some phenomena like food elicit emotional stress from some students, either in terms of the empathy they feel for those affected or from experiencing a natural hazard directly or through the experiences of family and friends.<br><br>Provide small-group support for students in need of focused skill instruction related to self-awareness, self-management, social awareness, relationship skills, and responsible decision making.<br><br>Increase positive reinforcement within the classroom for positive behavior. | Provide small-group support for students in need of focused skill instruction related to self-awareness, self-management, social awareness, relationship skills, and responsible decision making.<br><br>Increase positive reinforcement within the classroom for positive behavior. |
| | *Behavioral Supports* | | |
| | For all students, the use of Clear, consistent, and predictable consequences helps build a productive learning environment. | Ensure the use of a PBIS Behavior Contract during lab investigations and hands-on learning to ensure Layer 1 routines are supported.<br><br>With challenging academic learning, utilize PBIS Structured | Utilize the PBIS Check In Check Out (CICO) to engage all student stakeholders in creating a consistent learning environment. |

| | | | |
|---|---|---|---|
| | | Breaks throughout the learning cycle to support the multi-sensory environment of phenomena-based science. | |

| **Cross-Curricular Connections** | |
|---|---|
| *ELA/Literacy* | *Mathematics* |
| **RST.6-8.3** Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks. (MS-PS1-6)<br><br>**WHST.6-8.7** Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. (MS-PS1-6)<br>---<br>Throughout the design and learning of this standard, consider a final communication presentation of student designs and justifications for their work. This should include oral and written products, as well as community involvement of who they are presenting to. You could open up a showcase to all parents or invite local community members to the classroom to hear the presentations. | None listed |
| *Career & Skill Connections* | |
| Atmospheric science<br>Biology<br>Chemistry<br>Conservation science<br>Engineering<br>Environmental economist | Farming<br>Landscape architecture & design<br>Mechanical engineering<br>Meteorology<br>Urban planning |

# Section 3 – Planning Resources

## Overview

Science is not just a body of knowledge that reflects current understanding of the world; it is also a set of practices used to establish, extend, and refine that knowledge[1]. Our core science instruction must also allow for students to develop their science and engineering practices over time in addition to disciplinary core ideas. We know that children enter kindergarten with a surprisingly complex way of thinking about the world [2]. We know that students need sustained opportunities to work with and develop the underlying ideas and to appreciate those ideas' interconnections over a period of years rather than weeks or months. We know that in order for students to develop a sustained attraction to science and for them to appreciate the many ways in which it is pertinent to their daily lives, classroom learning experiences in science need to connect with their own interests and experiences. To this end, the National Research Council lays out a three-dimensional framework that is foundational to the development of the *Next Generation Science Standards (NGSS)*.

Dimension 1 describes the scientific and engineering practices (SEP). Dimension 2 describes the crosscutting concepts (CCC). Dimension 3 describes the core ideas (DCI) in the science disciplines and the relationships among science, engineering, and technology. All three of these dimensions must be interwoven in curriculum, instruction, and assessment.

## Getting Started with Using the Standards

The first step of any teacher in planning instruction is to deeply understand the end result that is required. The standards section of the NMIS Science document is placed first so that teachers have quick access to these requirements. The *NGSS* describe the essential learning goals and how those goals will be assessed at each grade level or band.

It is generally accepted that planning for instruction begins with the selection of the endpoint, or desired results of the instruction, and working backward through an instructional sequence to the beginning knowledge students have coming into the instruction. The description of such a process has been documented by Wiggins and McTighe in *Understanding by Design* (1998).

For the purpose of the NMIS Science document, a process for moving from the New Mexico STEM Ready! Science Standards to classroom instruction should minimally include the following[3]:

- Read the performance expectation, clarification statement, and assessment boundary.
- Read the disciplinary core idea in the foundation box.
    - Read the applicable disciplinary core idea essay in *A Framework for K–12 Science Education*, located in chapters 5, 6, 7, and 8. As you read, consider the following questions:
        - What are some commonly held student ideas about this topic?
        - How could instruction build on helpful ideas and confront troublesome

[1] National Research Council. (2012). *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas.* Committee on a Conceptual Framework for New K-12 Science Education Standards. Board on Science Education, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.
[2] National Research Council. (2007). *Taking Science to School: Learning and Teaching Science in Grades K-8.* Committee on Science Learning, Kindergarten through Eighth Grade. R.A. Duschl, H.A. Schweingruber, and A.W. Shouse (Eds.). Board of Science Education, Center for Education. Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.
[3] Bybee, Rodger W. (2013) *Translating the NGSS for Classroom Instruction.*

ideas?
- What prior ideas or concepts do students need to learn to understand this core idea?
- What level of abstractness is expected of students?
- What are some phenomena and experiences that could provide observational or experimental evidence that the DCI is an accurate description of the natural world?
- What representations or media would be helpful for students to use in making sense of the core idea?

- Read the science and engineering practices associated with the performance expectation.
  - Read the applicable SEP essay in *A Framework for K–12 Science Education* located in chapter 3, consider the following questions:
    - While the PE describes one SEP to be used, others will be needed in the instructional sequence, which ones and in what order will you use them?
    - How will each SEP be used to develop an understanding of the DCI?
    - What practices could students engage in to explore phenomena?
- Read the crosscutting concept associated with the performance expectation.
  - Read the applicable CCC essay in *A Framework for K–12 Science Education* located in chapter 4, consider the following questions:
    - How will the CCC indicated in the PE support the understanding of the core idea?
    - Are there other CCC that could also support learning the core idea?
- Read the connections box
  - When reading the connections to other DCI at this grade level that are relevant to the standard, consider the following question:
    - How can instruction be designed so that students note the connections between the core ideas?
  - When reading the articulation of DCI across grade levels that are relevant to the standard, consider the following questions:
    - Examine the standard at earlier grade levels, do they provide an adequate prior knowledge for the core ideas in the standard being reviewed?
    - Examine the standard at later grade levels, does the standard at this level provide adequate prior knowledge for the core ideas in the later standards?
  - When reading the CCSS in mathematics and English language arts (ELA), consider the following questions:
    - Should students have achieved these mathematics and ELA standards to engage in the learning of science, or could they be learned together?
    - In what ways do the referenced mathematics and ELA standards help clarify the science performance expectations?
    - Can any of the science core ideas be included as examples in the mathematics or ELA instruction?
- Create one or more descriptions of the desired results or learning goals for the instruction integrating the three dimensions in the foundation box.
- Determine the acceptable evidence for the assessment of the desired results.
- Create the learning sequence
  - The NMIS Science document includes aspects of instruction considerations that can be used to assist with this process.

- Create or utilize the summative assessment and check its alignment with the performance expectation.

## Engaging in the Science and Engineering Practices

Students provided sustained opportunities to engage in the practices of science and engineering better understand how knowledge develops and provides them an appreciation of the diverse strategies used to investigate, model, and explain the world. The practices for K–12 science classrooms are:

1. Asking questions (science) and defining problems (engineering)
    a. Science asks:
        i. What exists and what happens?
        ii. Why does it happen?
        iii. How does one know?
    b. Engineering asks:
        i. What can be done to address a particular human need or want?
        ii. How can the need be better specified?
        iii. What tools or technologies are available, or could be developed, for addressing this need?
    c. Both ask:
        i. How does one communicate about phenomena, evidence, explanations, and design solutions?
2. Developing and using models
    a. Mental models: functional, used for thinking, making predictions, and making sense of experiences.
    b. Conceptual models: allow scientists and engineers to better visualize and understand phenomena and problems.
    c. Are used to represent current understanding of a system (or parts of a system) under study, to aid in the development of questions or explanations, and to communicate ideas to others.
3. Planning and carrying out investigations
    a. Used to systematically describe the world and to develop and test theories and explanations of how the world works.
4. Analyzing and interpreting data
    a. Once collected, data are presented in a form that can reveal any patterns and relationships and that allows results to be communicated to others.
5. Using mathematics and computational thinking
    a. Enables the numerical representation of variables, the symbolic representation of relationships between physical entities, and the prediction of outcomes.
6. Constructing explanations (science) and designing solutions (engineering)
    a. Explanations are accounts that link scientific theory with specific observations or phenomena.
    b. Engineering solutions must include specifying constraints, developing a design plan, producing and testing models/prototypes, selecting among alternative design features to optimize achievement, and refining design ideas based on prototype performance.
7. Engaging in argument from evidence
    a. Scientists and engineers use reasoning and argumentation to make their case

concerning new theories, proposed explanations, novel solutions, and/or fresh interpretations of old data.

8. Obtaining, evaluating, and communicating information
    a. Being literate in science and engineering requires the ability to read and understand their literature. Science and engineering are ways of knowing that are represented and communicated by words, diagrams, charts, graphs, images, symbols, and mathematics.

STEM Teaching Tools develop briefs to assist STEM teachers with issues that arise in the teaching of STEM. Here are some briefs that address scientific practices. All of these can be found at [www.stemteachingtools.org/tools](http://www.stemteachingtools.org/tools)

*Why focus on science and engineering practices – and not "inquiry?" Why is "the scientific method" mistaken?* - STEM Teaching Tool #32

> For decades science education has engaged students in a version of science inquiry that reduces the investigation of the natural world to a fixed, linear set of steps—sometimes devoid of a deep focus on learning and applying science concepts. Rigid representations of a single "scientific method" do not accurately reflect the complex thinking or work of scientists. The new vision calls for engaging students in multifaceted science and engineering practices in more complex, relevant, and authentic ways as they conduct investigations.

*Practices should not stand alone: how to sequence practices in a cascade to support student investigations* – STEM Teaching Tool #3

> Science and engineering practices should strongly shape instruction—and be integrated with disciplinary core ideas and cross-cutting concepts. Some people might treat the practices as "stand alone" activities to engage students, but research shows that it is more effective to think about designing instruction as a cascade of practices. Practices should be sequenced and intertwined in different ways to support students in unfolding investigations.

*What is meant by engaging youth in scientific modeling?* - STEM Teaching Tool #8

> A model is a representation of an idea or phenomenon that otherwise may be difficult to understand, depict, or directly observe. Models are integral to the practice of science and are used across many disciplines in a variety of ways. Scientists develop, test, refine, and use models in their research and to communicate their findings. Helping students develop and test models supports their learning and helps them understand important aspects of how science and engineering work.

*Beyond a written C-E-R: supporting classroom argumentative talk about investigations* – STEM Teaching Tool #17

> Argumentation, a central scientific practice, relies on the coordination of claims, evidence, and reasoning (C-E-R). C-E-R scaffolds can help students compose a written argument for an investigation. However, there are additional important dimensions to argumentation beyond individually written claims. Classroom discussions that require students to make evidence-based claims and collectively build understanding also reflect argumentation. Several types of discussions can be used and can help build a supportive classroom culture.

*Why should students learn to plan and carry out investigations in science and engineering?* - STEM Teaching Tool #19

The NRC Framework for K-12 Science Education specifies eight science and engineering practices to be incorporated into science education from kindergarten through twelfth grade. One of these is planning and carrying out investigations. Although many existing instructional models and curricula involve engaging students in planned investigations, this tool will help you think about ways you can promote student agency by having them plan and conduct science investigations.

*How can assessments be designed to engage students in the range of science and engineering practices?* - STEM Teaching Tool #26

The new vision for K-12 science education calls for engaging students in three-dimensional science learning. This approach requires us to figure out new ways to assess student learning across these multiple dimensions—including the eight science and engineering practices. But there aren't many assessment tasks that require students to apply their understanding of core ideas using practices. In this tool, we describe how to use "task formats" to guide the development of such items. The formats can also spark ideas for designing classroom instruction.

*Integrating science practices into assessment tasks* – STEM Teaching Tool #30

This detailed and flexible tool suggests activity formats to help teachers create three-dimensional assessments based on real-world science and engineering practices. In response to this felt need being expressed among educators, researchers at the Research + Practice Collaboratory has developed a series of "task format" tables, which suggest different possible templates for student activities that integrate real-world science and engineering practices with disciplinary core ideas. This tool also combines two of the Research + Practice Collaboratory's major focuses: formative assessment and engaging learners in STEM practices. This tool offers between four and eight possible task formats for each of the science and engineering practices listed in the Next Generation Science Standards. It can be a great way for educators to brainstorm new activities or to adapt their existing lesson plans to this new three-dimensional vision.

*Engaging students in computational design during science investigations* – STEM Teaching Tool #56

Inquiry in science has become increasingly computational over the past several decades. The broad availability of computational devices, sensor networks, visualizations, networking infrastructure, and programming have revolutionized the way science and engineering investigations are carried out. Computational thinking practices enable unique modes of scientific inquiry that allow scientists to create models and simulations to generate data, and to understand and predict complex phenomena. K-12 science classrooms are natural contexts in which students can engage in computational thinking practices during their investigations.

*Designing 'productive uncertainty' into investigations to support meaningful engagement in science practices* – STEM Teaching Tool #60

We want students to engage from the earliest ages in science and engineering practices with sincere curiosity and purpose. Science investigations can be viewed as "working through uncertainty." However, 3D instructional materials often try to support engagement in science practices by making them very explicit and scaffolding the process to make it easy to accomplish—arguably, too easy. An alternative approach that emphasizes productive uncertainty focuses on how uncertainty might be strategically built into learning environments so that students establish a need for the practices and experience them as meaningful ways of developing understanding.

*Using science investigations to develop caring practices for social-ecological systems* – STEM Teaching Tool #61

Science investigations are a powerful way to foster caring practices for social-ecological systems. It encourages building relationships between learners and local ecosystems, highlighting the importance of multispecies justice and interconnectedness. The approach integrates diverse cultural perspectives, promotes empathy and ethical considerations, and supports transdisciplinary inquiry-based learning. Educators are urged to create opportunities for students to engage with their environment through observation, inquiry, and actions that benefit both humans and more-than-humans.

*How to integrate the argumentation from evidence practice into engineering design projects* – STEM Teaching Tool #63

The practice brief explains how to integrate argumentation from evidence into engineering design projects. It highlights the importance of teaching students to support engineering claims with specific evidence and reasoning, aligning with scientific practices. This process involves evaluating design merits, using diverse forms of evidence, and fostering collaborative problem-solving. The brief also addresses equity, suggesting accommodations to ensure all students can engage in argumentation, and provides actionable strategies for educators to create robust, argument-driven engineering projects.

*How can arguing from evidence support sensemaking in elementary science?* – STEM Teaching Tool #72

The practice brief focuses on the importance of integrating argumentation from evidence into elementary science education to support sensemaking. It highlights the need for students to engage in evidence-based discussions, propose and critique claims, and collaboratively build explanations for phenomena. The brief emphasizes creating equitable learning environments where diverse perspectives are valued and students develop skills in scientific reasoning. It also provides practical strategies for educators to foster a classroom culture that supports inquiry, curiosity, and the development of critical thinking skills.

## Crosscutting concepts

*A Framework for K-12 Science Education* identifies seven concepts that bridge disciplinary boundaries. These concepts provide students with an organizational framework for connecting knowledge from the various disciplines into a coherent and scientifically based view of the world. These crosscutting concepts are:

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

STEM Teaching Tools develop briefs to assist STEM teachers with issues that arise in the teaching of STEM. Here are some briefs that address scientific practices. All of these can be found at www.stemteachingtools.org/tools

*Prompts for integrating crosscutting concepts into assessment and instruction* – STEM Teaching Tool #41

> This set of prompts is intended to help teachers elicit student understanding of crosscutting concepts in the context of investigating phenomena or solving problems. These prompts should be used as part of a multi-component extended task. These prompts were developed using the *Framework for K-12 Science Education* and Appendix G of the Next Generation Science Standards, along with relevant learning sciences research.

> The planning and implementation of instruction in your classroom should allow your students multiple and sustained opportunities to learn disciplinary core ideas through the science and engineering practices, as well as using appropriate crosscutting concepts as lenses to understand the disciplinary core idea and its relationship to other core ideas.

## Planning Guidance for Culturally and Linguistically Responsive Instruction

"Equity in science education requires that all students are provided with equitable opportunities to learn science and become engaged in science and engineering practices; with access to quality space, equipment, and teachers to support and motivate that learning and engagement; and adequate time spent on science. In addition, the issue of connecting to students' interests and experiences is particularly important for broadening participation in science."[1]

In order to ensure our students from marginalized cultures and languages view themselves as confident and competent learners and doers of science within and outside of the classroom, educators must intentionally plan ways to counteract the negative or missing images and representations that exist in our curricular resources. The guiding questions below support the design of lessons that validate, affirm, build, and bridge home and school culture for learners of science:

> **Validate/Affirm:** How can you design your classroom to intentionally and purposefully legitimize the home culture and languages of students and reverse the negative stereotypes regarding the science abilities of students of marginalized cultures and languages?
>
> **Build/Bridge:** How can you create connections between the cultural and linguistic behaviors of your students' home culture and language and the culture and language of school science to support students in creating identities as capable scientists that can use science within school and society?

STEM Teaching Tools highlight ways of working on specific issues that arise during STEM teaching. Here are some tools that have been created to guide STEM instruction around the concept of culturally and linguistically responsive instruction. All of these can be found at [www.stemteachingtools.org/tools.](www.stemteachingtools.org/tools)

*How can we promote equity in science education?* - STEM Teaching Tool #15

> Equity should be prioritized as a central component in all educational improvement efforts. All students can and should learn complex science. However, achieving equity and social justice in science education is an ongoing challenge. Students from non-dominant communities often face "opportunity gaps" in their educational experience. Inclusive approaches to science instruction can reposition youth as meaningful participants in science learning and recognize their science-related assets and those of their communities.

*Building an equitable learning community in your science classroom* – STEM Teaching Tool #54

> Equitable classroom communities foster trusting and caring relationships. They make cultural norms explicit in order to reduce the risk of social injuries associated with learning together. Teachers are responsible for disrupting problematic practices and developing science classroom communities that welcome all students into safe, extended science learning opportunities. However, this is tricky work. This tool describes a range of classroom activities designed to cultivate communities that open up opportunities for all students to learn.

*How can you advance equity and justice through science teaching?* - STEM Teaching Tool #71

> Inequities are built into the systems of science education such that "students of color, students who speak first languages other than English, and students from low-income communities… have had limited access to high-quality, meaningful opportunities to learn science." Intersecting equity projects can guide the teaching and learning of science towards social justice. Science educators who engage in these projects help advance Indigenous self-determination (details) and racial justice by confronting the consequences of legacies of injustice and promoting liberatory approaches to education.

*Why you should stop pre-teaching science vocabulary and focus on students developing conceptual meeting first* – STEM Teaching Tool #66

> In New Mexico, and in the *Framework for K–12 Science Education,* we promote an inclusive educational environment for all students. Students should first develop conceptual understanding through sensemaking and observation. It is important to leverage students' home languages and diverse communication methods to enhance learning and participation, especially for multilingual and historically marginalized students. The approach promotes linguistic equity, encouraging environments where all forms of communication are valued, and suggests practical strategies for educators to integrate this methodology into their teaching practices.

*Focusing science and engineering learning on justice-centered phenomena across PK-12* – STEM Teaching Tool #67

> In the Framework vision for science education, students engage in active investigations to make sense of natural phenomena and analyze and build solutions to problems. Basing these investigations on justice-centered phenomena can be a powerful and rightful way to support science and engineering learning. Justice-centered investigations can open up important opportunities for students to engage in projects that support equity for communities and to see how the application of science and engineering are fundamentally entwined with political and ethical questions, dimensions, and decisions.

*Teaching STEM in ways that respect and build upon indigenous peoples' rights* – STEM Teaching Tool #10

> Indigenous ways of knowing are sometimes thought to be in opposition to and detrimental to the learning of Western Science or STEM. Consequently, indigenous ways of knowing are rarely engaged to support learning. If STEM learning is to be meaningful and transformative for Indigenous youth, respecting Indigenous peoples' rights and related critical issues, including Indigenous STEM, settler-colonialism, and decolonization, must be understood and explicitly addressed in Indigenous youths' informal and formal STEM learning experiences.

*How can formative assessment support culturally responsive argumentation in a classroom community?* - STEM Teaching Tool #25

> Argumentation has long been seen as an important practice in science and thus in science

education. Formative assessment can be used to help students value the contributions and perspectives of others as they engage in argumentation to make sense of natural phenomena. Educators can use these strategies to help foster argumentation that is culturally responsive, meaning it draws from and respects students' cultural resources, backgrounds, and personal experiences. Culturally responsive formative assessment happens within a community of learners where the teacher has cultivated explicit norms for increasing student-centered discourse, making decisions for their own purposes through democratic processes, and using clear guidelines for maintaining mutual respect.

*Engaging English learners in science and engineering practices* – STEM Teaching Tool #27

Routinely engaging all students in the practices of science and engineering is a crucial fixture of the new vision for K-12 science education. The practices can be seen as a barrier to participation for English Learners (ELs), or they can be viewed as an opportunity to provide rich instruction that builds science-related competencies and identities. Certain elements of the practices and related instructional approaches can be beneficial for students learning science while also learning the language of instruction.

*How can I promote equitable sensemaking by setting expectations for multiple perspectives?* - STEM Teaching Tool #47

In a phenomena-focused, 3D approach to science learning, students use science practices to consider each other's ideas based on available interpretations and evidence. To promote deep and equitable learning, plan purposefully to ensure that the various perspectives that students bring to making sense of phenomena are solicited, clarified, and considered. It is important to support students as they develop a shared understanding of the different perspectives in the group.

*Supporting observations, wonderings, systems thinking & "Should We" deliberations through Learning in Places* - STEM Teaching Tool #82

The practice brief emphasizes the importance of integrating observations, wonderings, and systems thinking in science education to support socioecological understanding and ethical decision-making. It advocates for field-based practices where learners and families engage with their environments, ask meaningful questions, and consider ethical implications. This approach values diverse cultural perspectives and aims to create equitable, place-based learning experiences that connect science with community well-being.

*Identifying local environmental justice, phenomena for science and engineering investigations* - STEM Teaching Tool #87

The practice brief highlights the need for science and engineering education to focus on local environmental justice (EJ) issues. It encourages engaging students with personally relevant EJ phenomena to develop a deeper understanding of these issues and to promote civic action. By investigating local EJ concerns, students can explore causes, impacts, and diverse perspectives, fostering individual and collective agency. The brief also emphasizes the importance of community-based learning and the integration of interdisciplinary approaches to address EJ and support frontline communities.

## UDL: Action and Expression

- Provide independent think time before students engage with others or responses are discussed.
- Ensure students have enough time to complete tasks and provide extra time if needed.
- Provide access to pre-cut materials, assistive tools, devices, and software.
- Offer flexibility and choice with the ways students demonstrate and communicate their understanding.
- Invite students to explain their thinking verbally or nonverbally with manipulatives, drawings, diagrams.
- Support fluency with graduated levels of support or practice.
- Apply and gradually release scaffolds to support independent learning.
- Support discourse with sentence frames or visible language displays.
- Support the development of organizational skills in problem-solving with access to templates, rubrics, and checklists.
- Post visible goals, objectives, and schedules.
- Provide opportunities for self-assessment and enable students to monitor their own progress.

Throughout the curriculum, students should be invited to share both their understanding and their reasoning about mathematical ideas with others. Offer flexibility and choice with the ways students demonstrate and communicate their understanding and invite students to explain their thinking verbally or nonverbally with manipulatives, drawings, diagrams. Provide independent think time before students engage with others or responses are discussed and support discourse with sentence frames or visible language displays. Ensure students have enough time to complete tasks and provide extra time if needed, as well as pre-cut materials, assistive tools, devices, and software. Support fluency with graduated levels of support or practice, applying and gradually releasing scaffolds to support independent learning. Support the development of organizational skills in problem-solving with access to templates, rubrics, and checklists and provide opportunities for self-assessment and enable students to monitor their own progress. Post visible goals, objectives, and schedules.

## UDL: Engagement

- Provide choice by inviting students to decide which problem to start with, select a subset of problems to complete, which strategy to use, the order they complete a task, etc.
- Provide access to a variety of tools or materials.
- Leverage curiosity and students' existing interests and invite students to name connections to their own lived experiences.
- Use visible timers and alerts to prepare for transitions.
- Chunk tasks into more manageable parts and check in with students to provide feedback and encouragement after each chunk.
- Differentiate the degree of difficulty or complexity by starting with accessible values.
- Periodically revisit community norms and provide group feedback that encourages collaboration and community.
- Provide ongoing feedback that helps students maintain sustained effort and persistence during a task.
- Encourage self-reflection and identification of personal goals.
- Provide access to tools and strategies designed to help students self-motivate and become more independent.

Students' attitudes, interests, and values help to determine the ways in which they are most engaged and motivated to learn. Provide access to a variety of tools, strategies, and materials designed to help students self-motivate and become more independent. Leverage curiosity and students' existing interests and invite students to name connections to their own lived experiences. Provide choice by inviting students to decide which problem to start with, select a subset of problems to complete, which strategy to use, the order they complete a task, etc. Use visible timers and alerts to prepare for transitions, and chunk tasks into more manageable parts and check in with students to provide feedback and encouragement after each chunk. Differentiate the degree of difficulty or complexity by starting with accessible values. Periodically revisit community norms and provide group feedback that encourages collaboration and community. Provide ongoing feedback that helps students maintain sustained effort and persistence during a task and encourage self-reflection and identification of personal goals.

## UDL: Representation

- Present content using multiple modalities.
- Annotate displays with specific language, different colors, shading, arrows, labels, notes, diagrams, or drawings.
- Provide appropriate reading accommodations.
- Support use of vocabulary, mathematical notation, and symbols with charts, pictures, diagrams, and tables.
- Highlight connections between representations to make patterns and properties explicit.
- Present problems or contexts in multiple ways, using diagrams, drawings, pictures, media, tables, graphs, and other mathematical representations.
- Use translations, descriptions, movement, and images to support unfamiliar words or phrases.
- Activate or supply background knowledge to build connections to prior understandings and experiences.
- Provide access to blank or partially-completed outlines, graphic organizers, or representations, to emphasize key ideas and relationships.
- Maximize transfer and generalization by naming connections to previous examples, inviting students to identify important details or features to remember

Teachers can reduce barriers and leverage students' individual strengths by presenting content using multiple modalities and annotating displays with specific language, different colors, shading, arrows, labels, notes, diagrams, drawings, etc. Support the use of vocabulary, mathematical notation, and symbols with charts, pictures, diagrams, and tables, and use translations, descriptions, movement, and images to support unfamiliar words or phrases. Present problems or contexts in multiple ways, using diagrams, drawings, pictures, media, tables, graphs, and other mathematical representations, and highlight connections between different mathematical representations to make patterns and properties explicit. Activate or supply background knowledge to build connections to prior understandings and experiences and maximize transfer and generalization by naming connections to previous examples, inviting students to identify important details or features to remember. Provide reading accommodations as needed, as well as blank or partially-completed outlines, graphic organizers, or representations, to emphasize key ideas and relationships.