FORMATIVE ASSESSMENT LESSON PLANS

ENGLISH LANGUAGE ARTS
SCIENCE

Grades 6-8

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INTRODUCTION

With support from the William and Flora Hewlett Foundation, the National Center for Research and Evaluation of Standards and Student Testing (CRESST) has developed a series of middle school history and science model units that integrate English language arts. The units are designed to offer content-area teachers examples of meaningful and authentic integration of Common Core literacy practices to teach and learn history or science content. The units also are designed to illustrate the use of formative assessment of the content and literacy practices where each assessment opportunity measures student content understanding and competency with a specific literacy practice. Lastly, the model units are also designed to demonstrate how Common Core literacy and formative assessment practices are used throughout an integrated series of lessons that "build up" to a larger summative assessment at the end of the unit.

INTEGRATED LITERACY IN SCIENCE LEARNING

Over the past two decades, science learning has been a major focus of education reform efforts. While policymakers, researchers, and educators alike have employed a variety of strategies in an attempt to address the struggles with science learning, the stark reality is that little, if any, progress has been made. Students continue to perform poorly on national measures of science achievement, like the National Assessment of Educational Progress (NAEP). Research in the area of science achievement and learning suggests that stronger articulation between adolescent literacy and the discipline of science are needed. Literacy practices associated with learning science - reading, writing, listening, and speaking - are an integral component to support learning for all students. While all students benefit from explicit literacy support in content areas, like science, it is especially important for students who struggle with reading and writing, and English Language Learners (ELLs). Although there have been a limited number of designed interventions with the aim of creating these explicit connections[1], there has been limited progress made on a large scale.

Recently, the advent of the Next Generation Science Standards (NGSS) and the Common Core State Standards (CCSS) has brought national attention to the importance of literacy in relation to science learning. Despite the crucial nature of the integration of literacy in science learning, curricular materials available to teachers do not provide examples of how to

[1] See Lee & Spratley (2010) for a review of designed interventions related to science teaching.

meaningfully and authentically integrate these practices as part of daily on-going instruction. The scarcity of resources for teachers has been much more pronounced at the secondary level, where teachers who are experts in their discipline lack the support required implementing integrated literacy approaches to teaching science.

Literacy Development, Science Content and Practices, and Assessment in Science Learning

The goal of this unit is to demonstrate how and why the integration of literacy activities in the service of scientific inquiry is key to learning science and improving literacy. The unit authors have used pedagogical principles grounded in research as a framework to guide instructional design. These pedagogical design principles incorporate literacy practices proven to enhance learning of science content while simultaneously emphasizing systematic use of on-going formative and summative assessment to support learning (Figure 1).

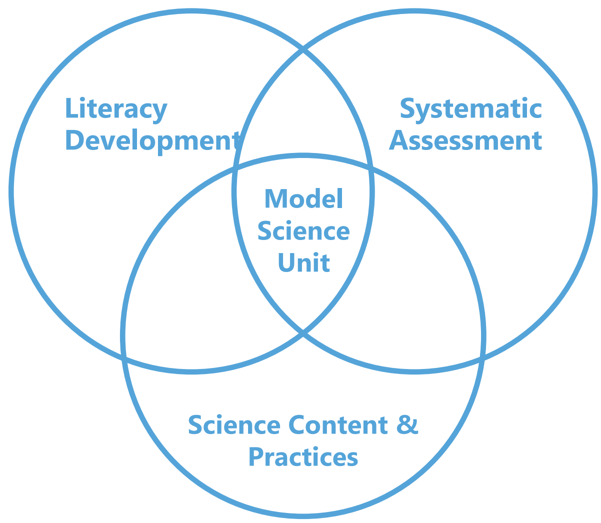

Figure 1. Research-based unit design

LITERACY DEVELOPMENT

Literacy practices[2] in this unit are defined as the types of reading, writing, listening, speaking, and language-based tasks and activities that students engage in the process of learning science. These are based on a scientific inquiry process shown in Figure 2. This version of

[2] Barton and Hamilton (2000) assert that "literacy is a social practice" (p. 7) and define literacy practices as "the general cultural ways of utilising written language which people draw upon in their lives" (p. 7). Practices are internal processes that are not observable. However, literacy events, "activities where literacy has a role" (p. 8) are "regular, repeated activities… linked to routine sequences" (p. 9). The role of texts within these literacy events are used to guide the approach included in this unit. Science learning in schools is a context in which literacy events play a crucial role.

[3] See Schwarz & White (2005) for more information.

scientific inquiry was selected because of its explicit use of modeling[3] as part of science learning. The literacy practices shown in Table 1 are illustrative of the types of literacy activities students can be expected to participate in while they are conducting scientific inquiry. Understanding the literacy practices associated with learning science is an important step in understanding the instructional routines, like annotation and double-entry journals, that support students' continued literacy development (see Appendix for a complete description of instructional routines and supports).

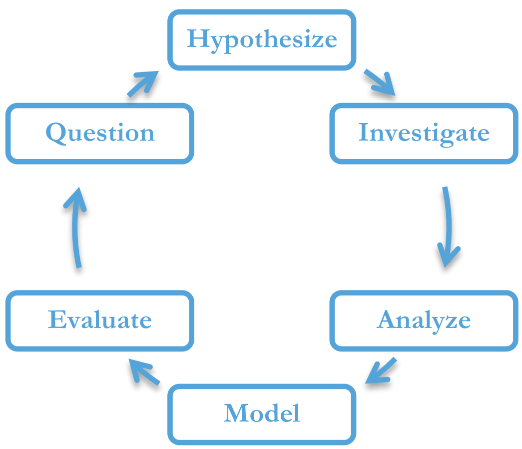

Figure 2. Scientific inquiry model used to guide the development of lessons in this unit. Based on work appearing in "Metamodeling Knowledge: Developing Students' Understanding of Scientific Modeling," by C. V. Schwarz and B. Y. White, 2005, *Cognition and Instruction, 23*(2), p. 173.

SCIENCE CONTENT AND PRACTICES

Learning science requires students to make authentic use of reading and writing, as detailed in Table 1 below. The lessons in this unit follow a cyclical structure that incorporates the use of a core set of instructional routines designed to support student engagement in scientific inquiry. Findings suggest that the routines and supports included improve science achievement and literacy for a wide-range of students, including students who have struggled with science for a number of reasons including issues related to language and literacy. Rooted in scientific inquiry, these instructional routines map onto the different literacy activities associated with learning science (Lee & Spratley, 2010) detailed below and are a key feature of the design of this unit.

Table 1

Literacy Practices Associated With Scientific Inquiry

Scientific Inquiry	Literacy Practices
Question	• Read science texts (claims and evidence, main ideas and supporting details) • Write notes and summaries of readings • Read past notes, investigation write-ups, and work collected in Science Notebook • Discuss current understandings with peers and teacher • Justify responses and explanations with evidence and reasoning from texts, past learning experiences, discussions, etc.
Hypothesize	• Formulate and record hypotheses • Read science texts to study investigation methods and procedures • Written record of methods and procedures • Discuss current understanding with peers and teacher • Justify responses and explanations with evidence and reasoning from texts, past learning experiences, discussions, etc.
Investigate	• Record data in Science Notebook • Record observations, initial impressions, concerns, and questions • Discuss data with peers and teacher • Formulate initial understandings • Use data and evidence to support explanations and responses
Analyze	• Read previous texts and notes during analysis of data • Read and analyze data in Science Notebook • Summarize and record findings • Formulate and record conclusions • Discuss current understanding with peers and teacher • Justify responses and explanations with evidence and reasoning using data, texts, past learning experiences, discussions, etc.
Model	• Read about different models and record notes • Write notes and summaries of readings • Use computer modeling software to support model development • Create models with clearly labeled components to explain scientific phenomena • Discuss current understanding with peers and teacher • Justify responses and explanations with evidence and reasoning from data, texts, past learning experiences, discussions, etc.
Evaluate	• Prepare multimedia presentations • Organize information logically and coherently • Discuss current understanding with peer and teacher • Use evidence to support explanations • Prepare and present investigation findings

ASSESSMENT

An equally important aspect of the unit design is its systematic use of on-going formative and summative assessment, both of which are tightly coupled to support the learning goals in the unit. Included throughout the unit lessons are examples of formative assessment opportunities that can occur formally or informally. The formative assessment opportunities are based on the cycle of formative assessment illustrated in Figure 3 (Heritage, 2010). The unit ends with a major culminating assignment that serves both formative and summative purposes.

Figure 3. Formative assessment process illustrating a continuous cycle of opportunities to gather evidence and take pedagogical action in support of student learning.

Formative assessment is embedded throughout the lessons to inform instruction and provide feedback to teachers and students alike, so that teaching and learning can be augmented as needed based on evidence of student learning. For this reason, the activities in this unit provide an initial structure for integrating literacy and science to reach specified learning goals, but do not include all the learning activities that may be required.

INSTRUCTIONAL ROUTINES AND SUPPORTS

Learning science can be challenging for many students. Often, students are unfamiliar with the type of language and syntax used to describe scientific concepts. The language of science may pose difficulties for students in general, and more so for students who have experienced language and literacy challenges. Teachers can support students to overcome these challenges by providing explicit instruction organized around a set of instructional routines. Instructional routines can support students by providing them with a set of tools that they can use to learn science as they navigate science text, participate in class discussions, and write for a variety of purposes.

The instructional routines and supports included in the Appendix are referenced throughout the series of lessons presented in this model unit. The routines are designed to help teachers prepare and engage in instruction that supports students in meeting the learning expectations expressed in the Literacy in History/Social Studies, Science and Technical Subjects (6-12) Common Core State Standards and the Next Generation Science Standards.

LITERACY ROUTINE EXAMPLES

- **ANNOTATION** Students read text closely and identify key text features to support reading comprehension and conceptual knowledge acquisition. Specific symbols are used to mark key text features. Annotation supports students' comprehension. Students learn how to identify important text elements, including key content vocabulary, definitions of concepts, main ideas, claims, supporting details, and evidence.

How and Why Do Fireflies Light Up? **LEXILE 1240L**

1 Marc Branham, an assistant professor in the department of entomology and nematology at the University of Florida, explains. Fireflies produce a chemical reaction inside their bodies that allows them to light up. This type of light production is called bioluminescence. The method by which fireflies produce light is perhaps the best known example of bioluminescence. When oxygen combines with calcium, adenosine triphosphate (ATP) and the chemical luciferin in the presence of luciferase, a bioluminescent enzyme, light is produced. Unlike a light bulb, which produces a lot of heat in addition to light, a firefly's light is cold light, without a lot of energy being lost as heat. This is necessary because if a firefly's light-producing organ got as hot as a light bulb, the firefly would not survive.

- **DOUBLE OR TRIPLE ENTRY JOURNALS** Students use these tables to organize information and ideas drawn from text, discussions, and other sources. The use of Double Entry Journals supports students in learning how to document and organize information as an intermediary step for exposition of oral and written ideas.

Why do fireflies glow?	How do you know? What is your evidence? Include source.
• Chemical reactions in the body • Superoxide anion is key to glow	Light production in fireflies is due to bioluminescence (Scientific American article and National Geographic)

- **SUMMARIZATION** Students distill information from text to include only the most important information and details about a given topic or idea. Summarization supports students' comprehension and content learning. When students are involved in the identification of essential main ideas and preparation of a written summary, they have additional opportunities to revisit content.

Summary: Mendeleev and the Periodic Table

The periodic table is a tool used to organize and group elements with shared characteristics. The version we use today was created using Dmitri Mendeleev's model at a time when not all the elements we see today had been discovered. What was special about Mendeleev's model is that he was able to predict properties of unknown elements. He left gaps in his periodic table model to allow for these element discoveries. Mendeleev used the atomic mass of elements to organize these and continued grouping according to other shared element properties. The text states that "a good model is able to incorporate newly understood information" (p. 1). Mendeleev's model has done just that, withstanding the test of time. New elements have been discovered and have fit nicely with Mendeleev's model of the periodic table.

- **EXPLANATION** Students use their knowledge of scientific concepts to generate an explanation of a given phenomenon or concept. When students generate oral and written explanations, they learn to establish claims, identify supporting evidence, and create logical connections to describe their reasoning. These are essential in science learning.

- **ARGUMENTATION** Students use scientific and engineering practices to evaluate and respond to claims and evidence about a given topic or concept. Students involved in argumentation take stances and establish claims in relation to these positions. They must carefully identify and select appropriate evidence to support their claim and provide sufficient reasoning to support their argument.

- **INVESTIGATION, ANALYSIS, AND CONCLUSION** Students use their knowledge of the scientific method to write a detailed account of inquiry and investigation to demonstrate confirming or disconfirming evidence of a given hypothesis. Investigation supports students' ability to document their inquiries, learning development, and exposition of reasoning and analysis.

- **SCIENCE NOTEBOOKS** Students create a record of learning over time, documenting science concept learning. The Science Notebook is an important tool students can use to collect a variety of classroom artifacts over time. The Science Notebook can be used to describe a trajectory of science learning and is also a valuable self-reflection tool.

FORMATIVE ASSESSMENT

Formative assessment opportunities are clearly marked throughout the unit lessons. These include suggested ways to gather evidence of learning in the context of the tasks and activities within the lesson. The success criterion included in each lesson is used to determine evidence of learning.

READING

Teachers can gather evidence of student learning whenever students are engaged in reading by:

- Observing students as they read and annotate
- Checking in with students about their understanding of the text
- Collecting and studying student annotations, checking for accuracy
- Collecting and studying student Double Entry Journals and Triple Entry Journals, focusing on identification of main ideas, supporting details, and reasoning
- Reading students' written summaries, using a rubric (see Appendix) to check for comprehension and understanding

DISCUSSION

Discussion is a valuable evidence-gathering opportunity. Teachers listen to student responses to make in-the-moment instructional moves based on students' current thinking. These understandings support teachers as they consider student knowledge and instructional needs that should be addressed in the current lesson or in future lessons.

Brief or lengthy discussions are sources of valuable information for teachers. Teachers listen to student responses to make instructional decisions based on students' current thinking. These understandings will support teachers to consider student knowledge and possible misconceptions that may need to be addressed in the *current* lesson or in *subsequent* lessons.

Teachers can gather evidence of student learning whenever students are engaged in reading by:

- Observing students and listening to them talk as they formulate ideas and conjectures about a specific topic
- Checking in with students about their conjectures, pressing student thinking

PEER AND SELF-ASSESSMENT

While students discuss clarifications, revisions, and/or new understandings with peers, teachers attend to student responses and continue to gather evidence of student learning. Teachers can gather evidence of learning by listening to peer-to-peer conversations, studying student artifacts to documented changes in student thinking, like Science Notebooks completed Double Entry Journals, or exit slips, and reviewing charted student responses at the end of a period.

WRITING

Throughout the unit students will have numerous opportunities to write. Whether students write explanations of observed science phenomena, document data collection throughout investigations, or write analyses and conclusions of data in lab reports, these are all important sources of evidence of learning that will support teachers in making informed instructional decisions to push student thinking forward.

UNIT OVERVIEW

Lesson Set	Description
Set I Lessons 1-6	The first lesson set focuses on developing students' understanding of foundational concepts about matter. These first lessons include study of the following: • the structure of atoms • simple and complex molecules • shared characteristics and structures of pure substances These topics support students' understanding and explanation of what happens, atomically/molecularly speaking, in chemical reactions. Assessment opportunities in this lesson set include: • develop models that describe atomic composition of molecules • identify atom and molecule components and describe how these relate
Set II Lessons 7-9	The second lesson set focuses on developing students' understanding of chemical reactions. These lessons include explorations about: • chemical reactions • characteristics of chemical reactions • physical vs. chemical change These topics support students' ability to determine whether a chemical reaction has taken place. Assessment opportunities in this lesson set include: • use simple/complex molecule models to describe pure substances before and after chemical interactions • analyze and interpret data based on characteristic properties of pure substances to determine whether a chemical reaction has occurred
Set II Lessons 10-14	The third lesson set extends student knowledge of chemical reactions to include considerations of the role of energy; it's relationship to the electromagnetic spectrum, and the visual light spectrum. In this lesson set, students explore: • the role of energy in breaking bonds during chemical reactions • energy's effect on matter before, during, and after a chemical reaction • the relationship between energy and the visual light spectrum These lessons are designed to support students' understanding of the role of energy in chemical reactions. Assessment opportunities in this lesson set include: • explanations of the role of energy and temperature in exothermic and endothermic reactions • descriptions of the relationship between energy and light on the electromagnetic spectrum

CULMINATING TASK OVERVIEW

Lesson Set	Description
Culminating Assessment	The culminating assessment is comprised of two parts: 1 an investigation 2 an argumentation writing task In Part I, students investigate the amount of energy required to produce the variety of colors observed during a display of fireworks. In Part II, students construct an argument in response to the question, "How do fireworks get their colors?" Students use the investigation data they have collected and analyzed to support their written response.

UNIT TIMELINE

Lesson	Lesson Title	Time Required
0	How do fireworks get their colors?	45-60 minutes
1	What is an atom?	90 minutes
2	What makes objects attract or repel each other?	90 minutes
3	What's different between an atom and a molecule?	45-60 minutes
4	What is the periodic table?	Three to Four 45-minute sessions
5	What is a simple molecule?	90 minutes
6	What is a complex molecule?	90 minutes
Assessment I	Atoms & Molecules	45-60 minutes
7	What is a chemical reaction?	90 minutes
8	What are characteristics of chemical reactions?	90 minutes
9	What is the difference between chemical and physical change?	Two to Three 45-60 minute sessions
Assessment II	Identify an Unknown Substance	90-120 minutes
10	What is the role of energy in a chemical reaction?	90 minutes
11	What happens to matter when thermal energy is added or removed?	45-90 minutes
12	Why do fireflies glow?	90 minutes
13	What is light?	90-120 minutes
14	What is the relationship between light, energy, and the electromagnetic spectrum?	90 minutes
Culminating Assessment	How do fireworks get their colors?	90-120 minutes

SET I: LESSONS 1-6

Common Core State Standards

- Cite specific textual evidence to support analysis of science and technical texts. CCSS.ELA-LITERACY.RST.6-8.1
- Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions. CCSS.ELA-LITERACY.RST.6-8.2
- Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks. CCSS.ELA-LITERACY.RST.6-8.3
- 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). CCSS.ELA-LITERACY.RST.6-8.7
- Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic. CCSS.ELA-LITERACY.RST.6-8.9
- Develop the topic with relevant, well-chosen facts, definitions, concrete details, quotations, or other information and examples. CCSS.ELA-LITERACY.WHST.6-8.2.B
- Use precise language and domain-specific vocabulary to inform about or explain the topic. CCSS.ELA-LITERACY.WHST.6-8.2.D
- 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. CCSS.ELA-LITERACY.WHST.6-8.8
- Draw evidence from informational texts to support analysis, reflection, and research. CCSS.ELA-LITERACY.WHST.6-8.9

STANDARDS CONTINUED

Common Core State Standards

- Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation. CCSS.ELA-LITERACY.SL.8.4
- Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. CCSS.ELA-LITERACY. SL.8.5

Next Generation Science Standards: Performance Expectations

- Develop models to describe the atomic composition of simple molecules and extended structures. MS-PS-1-1
- Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred. MS-PS-1-2
- Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system. MS-PS-3-2

Next Generation Science Standards: Disciplinary Core Ideas

- Structures and Properties of Matter. PS1.A

  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.

  Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals).

- Relationship Between Energy and Forces. PS3.C

  When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object.

STANDARDS CONTINUED

- **Next Generation Science Standards: Crosscutting Concepts**
  - Scale, Proportion, and Quantity
    Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.
  - Systems and System Models
    Models can be used to represent systems and their interactions – such as inputs, processes, and outputs – and energy and matter flows within systems.
- **Science and Engineering Practices**
  - Asking questions and defining problems
  - Developing and using models
  - Planning and carrying out investigations
  - Analyzing and interpreting data
  - Constructing explanations and designing solutions
  - Obtaining, evaluating, and communicating information

SET II: LESSONS 7-9

Common Core State Standards

- Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks. CCSS.ELA-LITERACY.RST.6-8.3
- 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). CCSS.ELA-LITERACY.RST.6-8.7
- Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic. CCSS.ELA-LITERACY.RST.6-8.9
- Develop the topic with relevant, well-chosen facts, definitions, concrete details, quotations, or other information and examples. CCSS.ELA-LITERACY.WHST.6-8.2.B
- Use precise language and domain-specific vocabulary to inform about or explain the topic. CCSS.ELA-LITERACY.WHST.6-8.2.D
- 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. CCSS.ELA-LITERACY.WHST.6-8.8
- Draw evidence from informational texts to support analysis, reflection, and research. CCSS.ELA-LITERACY.WHST.6-8.9
- Come to discussions prepared, having read or researched material under study; explicitly draw on that preparation by referring to evidence on the topic, text, or issue to probe and reflect on ideas under discussion. CCSS.ELA-LITERACY.SL.8.1.A

STANDARDS CONTINUED

- **Next Generation Science Standards: Performance Expectations**
  - Delineate a speaker's argument and specific claims, evaluating the soundness of the reasoning and relevance and sufficiency of the evidence and identifying when irrelevant evidence is introduced. CCSS.ELA-LITERACY.SL.8.3
  - Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred. MS-PS-1-2
- **Next Generation Science Standards: Disciplinary Core Ideas**
  - Structures and Properties of Matter. PS1.A

    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.
  - Chemical Reactions. PS1.B

    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 reactants.
- **Next Generation Science Standards: Crosscutting Concepts**
  - Patterns
    Macroscopic patterns are related to the nature of microscopic and atomic-level structure.
- **Science and Engineering Practices**
  - Asking questions and defining problems
  - Planning and carrying out investigations
  - Analyzing and interpreting data
  - Constructing explanations and designing solutions
  - Engaging in argument from evidence
  - Obtaining, evaluating, and communicating information

SET III: LESSONS 10-14

Common Core State Standards

- Cite specific textual evidence to support analysis of science and technical texts. CCSS.ELA-LITERACY.RST.6-8.1
- Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions. CCSS.ELA-LITERACY.RST.6-8.2
- Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks. CCSS.ELA-LITERACY.RST.6-8.3
- 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). CCSS.ELA-LITERACY.RST.6-8.7
- Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic. CCSS.ELA-LITERACY.RST.6-8.9
- Write arguments focused on discipline-specific content. CCSS.ELA-LITERACY.WHST.6-8.1
- Develop the topic with relevant, well-chosen facts, definitions, concrete details, quotations, or other information and examples. CCSS.ELA-LITERACY.WHST.6-8.2.B
- Use precise language and domain-specific vocabulary to inform about or explain the topic. CCSS.ELA-LITERACY.WHST.6-8.2.D
- 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. CCSS.ELA-LITERACY.WHST.6-8.7

STANDARDS CONTINUED

Common Core State Standards

- 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. CCSS.ELA-LITERACY.WHST.6-8.8
- Draw evidence from informational texts to support analysis, reflection, and research. CCSS.ELA-LITERACY.WHST.6-8.9
- Come to discussions prepared, having read or researched material under study; explicitly draw on that preparation by referring to evidence on the topic, text, or issue to probe and reflect on ideas under discussion. CCSS.ELA-LITERACY.SL.8.1.A

Next Generation Science Standards: Performance Expectations

- Develop models to describe the atomic composition of simple molecules and extended structures. MS-PS-1-1
- Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred. MS-PS-1-2
- Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed. MS-PS-1-4
- 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. MS-PS-1-5
- Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave. MS-PS-4-1

STANDARDS CONTINUED

Next Generation Science Standards: Disciplinary Core Ideas

- Chemical Reactions. PS1.B

  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 reactants.

  The total number of each type of atom is conserved, and thus the mass does not change.

- Wave Properties. PS4.A

  A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude.

Next Generation Science Standards: Crosscutting Concepts

- Cause and Effect
  Cause and effect relationships may be used to predict phenomena in natural or designed systems.

- Patterns
  Graphs and charts can be used to identify patterns in data.

- Energy and Matter
  Matter is conserved because atoms in physical and chemical processes.

Science and Engineering Practices

- Asking questions and defining problems
- Developing and using models
- Planning and carrying out investigations
- Analyzing and interpreting data
- Constructing explanations and designing solutions
- Engaging in argument from evidence
- Obtaining, evaluating, and communicating information