STC

SCIENCE AND TECHNOLOGY CONCEPTS™
MIDDLE SCHOOL

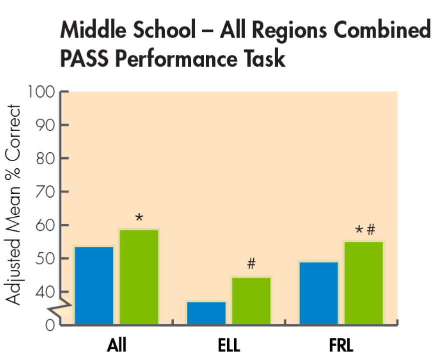
Response to the EdReports Evaluation of STCMS Curriculum

Science and Technology Concepts™ Middle School (STCMS) is a hands-on, inquiry-centered, research-based curriculum proven to raise test scores in science, math, and reading and close the achievement gap among English language learners and economically disadvantaged students. Each of the program's nine units are designed around a coherent learning progression that addresses NGSS standards and three-dimensional learning and integrates phenomena and engineering design challenges to bring science to life in the classroom and make learning relevant to all students.

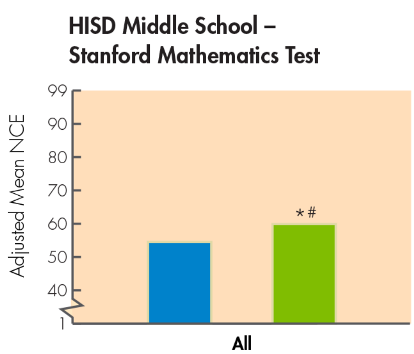
STCMS Improves Student Achievement

In a US Department of Education 5-year i3 grant, the Center for Research in Education Policy at the University of Memphis conducted a randomized control study involving over 60,000 students annually. They longitudinally followed elementary and middle school students in three diverse areas of the country to study the effectiveness of STC and STCMS curriculums. **The study demonstrated statistically significant and educationally meaningful improvements in student achievement on standardized state tests and performance-based assessments.** For example, in participating Houston Independent School District middle schools, **reading, math, and science scores increased for all students, including English language learners and economically disadvantaged students.** The current STCMS units were designed and developed from the lineage of the research-based STC program and draw pedagogy and practices from more than 30 years of hands-on, inquiry-based science curriculum development.

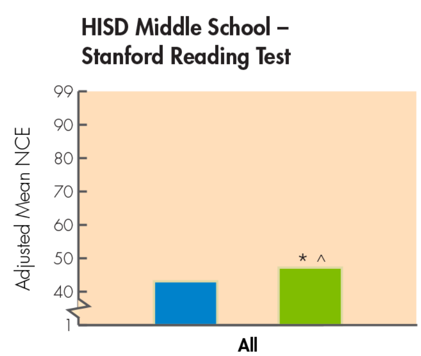
Science Scores Increased



Math Scores Increased



Reading Scores Increased



* statistically significant results # educationally meaningful results

LASER group Comparison group

STCMS Addresses the Three Dimensions of NGSS

Each STCMS unit was developed to address a targeted bundle of NGSS performance expectations. During development, those performance expectations were broken down into smaller three-dimensional components to guide the storyline and develop lessons and investigations. As a result, students engage with disciplinary core ideas, science and engineering practices, and crosscutting concepts to build the skills and knowledge needed for the targeted performance expectation bundles. Each lesson provides teacher support in understanding and weaving together the three-dimensional elements being addressed.

Lesson 5 Kinetic and Potential Energy

Alignment to Next Generation Science Standards

- **MS-PS3-1:** Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.
- **MS-PS3-2:** 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-PS3-5:** Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.

Investigation 5.2 addresses the NGSS **performance expectation MS-PS3-1** as students **describe the relationships** of kinetic energy to the mass of an object and to the speed of an object and **construct and interpret graphical displays of data**.

Both Investigations 5.1 and 5.2 address NGSS **performance expectation MS-PS3-2** because students need to **plan and develop a model** to describe when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system. In addition, these investigations support NGSS **performance expectation MS-PS3-5** in that **students must account for how kinetic energy increases and then decreases during their investigation**. In both investigations, potential energy is transformed into kinetic energy and is then transferred to the sand when the ball comes to a stop.

Investigations 5.1 and 5.2 align to the **science and engineering practices of developing and using models and planning and carrying out investigations** because students are responsible for developing their plan, using a model, and then carrying out the investigations. During data analysis, students see that **scientific knowledge is based on empirical evidence**. After both investigations, students **evaluate and communicate their derived information**. Also, for both investigations, students were involved in **constructing explanations and designing solutions**. The models they developed were in response to **designing a solution** that would **explain the relationship** between mass and weight and model gravitational potential and kinetic energies, respectively.

Investigations 5.1 and 5.2 also support the **crosscutting concepts of cause and effect** as students observe changes in mass affect weight, gravitational potential, and kinetic energies. They construct and observe **systems and system models**. Students use their models to demonstrate **stability and change**. With the support of Building Your Knowledge readings and Reflecting On What You've Done activities, students understand that matter has energy and changes to matter (in terms of position and mass) can affect stability and types of energy.

The hands-on, inquiry-based design of STCMS units ensures that students are directly engaged with phenomena and have opportunities to question, investigate, and build an understanding of disciplinary core ideas using science practices through the lens of relevant crosscutting concepts. A coherent learning progression is the backbone of each unit, allowing students to reflect on the phenomenon of a unit driving question, investigate and build their understanding from lesson to lesson, and apply knowledge gained to a performance task at the end of each unit.

Matter and Its Interactions
Concept Storyline

Unit Driving Question: **How does matter and its interactions affect everyday life?**

Lesson 1: *Pre-Assessment: Matter and Its Interactions*

Focus Question: **What do you know about matter?**

Students perform short, simple investigations that evaluate their existing knowledge of one or more concepts related to matter and its interactions. Students make observations of pure substances and mixtures and determine if new substances are formed. Students also evaluate predictions, use evidence to support claims, and infer cause-and-effect relationships.

Lesson 2: *The Nature of Matter*

Focus Question: **What can properties of matter help you determine?**

Students observe and describe samples of matter based on their physical and chemical properties (including solubility, and reactivity). Students also identify mystery samples on the basis of their physical and chemical properties.

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Lesson 3: *Density Makes a Difference*

Focus Question: **How can density be used to identify a substance and predict how it will behave under different conditions?**

Students compare the densities of different substances, including liquids and irregularly shaped objects. Students also make and test predictions about the floating of solids in liquids and use their findings to re-create the density bottle they explored in the Pre-Assessment.

Lesson 4: *Just a Phase*

Focus Question: **How is energy related to physical changes in matter?**

Students record the temperature of water as it melts, warms, and boils and then make connections with molecular-level observations in a computer simulation of the same experiment. Students also apply their understanding of the law of conservation of mass to plan and carry out investigations of the mass of water as it melts or freezes in a sealed container.

Lesson 5: *Building Blocks of Matter*

Focus Question: **How can you use a model to describe the composition of matter?**

Students rotate through stations to collect information about 16 different element samples. Next, students combine elements and create models of simple molecules using plastic atoms and computer simulations.

Lesson 6: *Pure Substances and Mixtures*

Focus Question: **How can mixtures be separated?**

Students observe and describe samples of pure substances and mixtures. Students use chromatography to separate inks, and distill flavoring from a carbonated beverage. Students apply engineering skills to design a method for removing impurities from rock salt.

Lesson 7: *Reacting Chemically*

Focus Question: **How can the properties of matter be used to determine if a chemical reaction has occurred?**

Students analyze and interpret data on the properties of substances before and after different chemical reactions. Students also use their data to support the claim that a new substance has been formed. Chemical reactions include: the electrolysis of water; formation of precipitates; and combination of sodium bicarbonate, calcium chloride, and phenol red.

Lesson 8: *Releasing Energy*

Focus Question: **What is the relationship between changes in substances and changes in thermal energy?**

Students investigate a physical change that releases energy (dissolving calcium chloride in water). Next, students use data from their investigation to design a device that provides heat on demand: an instant hot pack.

Lesson 9: *Conservation of Matter*

Focus Question: **What happens to matter in a chemical reaction?**

Students will apply their understanding of the law of conservation of matter to create models that explain situations in which matter seems to appear or disappear. Chemical reactions include dissolving an effervescent tablet in water and burning steel wool.

Lesson 10: *Compounds from Natural Resources*

Focus Question: **How are synthetic compounds made and used?**

Students read about and investigate natural resources that undergo chemical reactions to produce synthetic materials. Students plan and conduct an investigation to determine which solutions can be combined with sodium alginate to form a gelatinous product.

Lesson 11: *Assessment: Matter and Its Interactions*

Focus Question: **How can we use our knowledge of matter and its interactions to solve problems?**

The unit concludes with a two-part assessment. The first part is a Performance Assessment, in which students demonstrate their content knowledge and science and engineering skills to design a cold pack using one of five chemical compounds. Students must set up their own experiments and justify their selection based on safety for humans, safety for the environment, and cost of material per gram. In the second part, students complete a Written Assessment covering the performance expectations, disciplinary core ideas, crosscutting concepts, and science and engineering practices covered in this unit.

More resources for teachers and students found at:
www.carolinascienceonline.com
www.ssec.si.edu/STCMS

CREDIT: NASA/Dana Berry

STCMS Explores Phenomena Through Experiential Learning

Throughout each unit, phenomena and problems weave a conceptual storyline that drives and engages with three-dimensional learning of the targeted performance expectations. In each lesson, text, images, and hands-on materials are combined to directly engage students with phenomena and/or problem solving, and drive learning of key elements of the targeted performance expectation dimensions. Many units utilize online videos or computer simulations to directly engage students in phenomena and problems that cannot be brought into the classroom. For example, in *Weather and Climate Systems*, each lesson's focus question connects to phenomena that influence weather and climate, such as different surfaces warming and cooling at different rates, how air and water move through the atmosphere, and how temperature, salinity, and wind can affect ocean currents. Questions about these phenomena engage students in making sense of natural phenomena in meaningful ways across multiple lessons. Since studying weather and climate patterns involves observation of large-scale Earth systems, developing and using models (Lessons 2, 4, and 5) is an important skill that connects students to the unit's central phenomena. Students have opportunities to engage with local weather conditions (Lesson 1) and climate projections (Lesson 10) to drive sensemaking. Images in the Student Guide enhance students' connections to phenomena, and the accompanying questions help further drive discussion and sensemaking. In addition, students view a Smithsonian Environmental Research Center video, "Ecosystems on the Edge: Wetlands of the Future" (Lesson 11), to engage with and discuss current research around phenomena they have investigated in the unit.


Lesson 11

Impact of Climate Change

FOCUS QUESTION How does climate change impact Earth's systems?

Introduction

In previous lessons, you studied the types of data that scientists use to track changes in climate. You studied multiple graphs and examined data on changes in the concentration of carbon dioxide in the atmosphere, sea surface temperatures, glacial mass, spring snow cover, arctic sea ice extent, permafrost thawing, land and ocean surface temperatures, and other variables related to climate change. In this lesson, you will study how scientists use this data to make **climate models**. Scientists use the models to make projections by looking for trends in climate data. They estimate the impact those trends will have in the future.

Figure 11.1
Climate change can affect the ice that polar bears depend on for habitat and hunting.
CREDIT: Florida Stock/Shutterstock.com

Objectives for This Lesson

- Consider how scientists make predictions about climate.
- Study federal climate change projections for a region of the United States.
- Develop climate change–related policy recommendations.
- Observe a method to monitor the effects of increased carbon dioxide (CO_2) on wetlands.

Getting Started

1. In past lessons, you learned about climate and climate change. In this lesson, you will evaluate how evidence of climate change can be used to make projections of the impacts of climate change in the future. You will explore how scientists simulate and study the effects of climate change. Remember to follow your teacher's instructions carefully throughout the lesson and record your predictions and data neatly and accurately.
2. Recall the research you and your classmates did in Lesson 10 and what you have learned about climate so far. Use what you know to answer the following questions in your science notebook:
   a. What are the causes of climate change?
   b. What are the impacts of climate change?
3. Read Building Your Knowledge: *Consensus on Global Climate Change and Future Climate Predictions*. Then, answer the following questions in your science notebook:
   a. What did the Intergovernmental Panel on Climate Change (IPCC) determine about climate change in the late 1980s?

continued

Olympic National Park - Blue Glacier

1899

2008

Figure 11.2
The Blue Glacier in Olympic National Park has receded significantly since 1899, as these photos show. Global climate change may be responsible for events such as these.
CREDIT: 1899: Olympic National Park archives; 2008: Jim Patterson, ONP

176 STCMS™ / Weather and Climate Systems

Lesson 11 / Impact of Climate Change 177

STCMS Assessment

Each STCMS unit provides multiple and varied opportunities for teachers to elicit observations of student learning and for students to measure and reflect on their own understandings. Opportunities are provided for students to engage in class discussions, share ideas in small groups, and evaluate text to address all three dimensions of the targeted performance expectations. The first lesson of each unit is a pre-assessment that allows students to reflect on their own experiences with and prior knowledge about the phenomena and ideas that will be explored during the unit. In every lesson, students reflect on their learning through "Exit Slip" prompts at break points within each lesson and through "Reflecting on What You've Done" prompts at the end of each lesson. Responses to these prompts provide an overall snapshot of how students are progressing toward proficiency in key elements of the three dimensions being addressed, however they are not the only formative assessment opportunities provided in a unit. Each STCMS Teacher Edition includes a section titled "Tab 4: Best Practice for Assessment Using STCMS," which outlines the STCMS assessment approach to NGSS. The types and locations of formative and summative assessments within the units are addressed here, including information on the pre-assessment lesson, student self-assessments, and providing student feedback. This section is intended to guide teachers in using the assessments to inform instructional planning, assist students in evaluating their own learning and revising their work, and foster student ownership of their learning.

Teachers are provided sample answers and procedural guidance to help them evaluate learning progressions of the three-dimensional elements. Throughout the unit, students document their learning. The summative assessment, which occurs in each unit's final lesson, is designed with the understanding that not all NGSS three-dimensional elements can be easily assessed by written tasks alone. For example, in the performance assessment for *Matter and Its Interactions*, students apply the knowledge and skills they have acquired to produce and evaluate a design for a chemically activated cold pack. Then they respond to written assessment items aligned to concepts covered in the unit. The written items and performance tasks are like puzzle pieces and need to be examined together. When students' assessment results are combined, they provide evidence of that students' three-dimensional learning of the targeted performance expectations of the unit.

STCMS Leverages Students' Prior Knowledge

STCMS was developed based on knowledge and research concerning best practices in science instruction. This body of knowledge outlines the importance of eliciting and leveraging students' prior knowledge and experiences. In Tab 2 of each Teacher Edition, "Implementing STCMS," the importance of allowing students to "link their lives to what they are learning in science" is outlined:

> The science classroom may be the only place for many students to learn why science matters in their lives. However, when students enter the classroom, they do not leave their cultural worldview behind. Research shows that allowing science understanding to grow out of students' own experiences allows them to draw meaningful connections between their everyday situation and science. When students see that science is meaningfully related to circumstances in their own lives, they develop science-linked identities. When educators take the time to allow students to develop these links, students see that science is relevant to them and the things they care about. (Tab 2: Implementing STCMS, pg. 3).

Each STCMS unit elicits and leverages students' prior knowledge beginning in the opening activity of the first lesson. This enables students to express and discuss knowledge they bring to science class and build and refine that knowledge as they progress through the unit's investigations. For example, in *Ecosystems and Their Interactions*, students engage in developing an understanding of phenomena and problems within the field of ecology. The Teacher Edition Unit Overview (Tab 1, pg. 4) prepares teachers for these opening discussions by providing examples of prior knowledge and experience that students may have related to the unit's phenomena. Lesson 1 introduces the central phenomena of ecosystems and the interactions within them. In the Student Guide, students are prompted with an opening question, "What do you think an ecosystem is?" Responding to this requires them to uncover their prior knowledge. An image in the Student Guide (pg. 2) shows a coral reef ecosystem beneath the surface of the ocean. The combined prompts of the question and the image of the reef ecosystem launches the unit by helping students uncover what they already know and understand about ecosystems as well as their misconceptions. The lesson's subsequent activities continue to elicit prior knowledge from students regarding the biotic and abiotic resources in ecosystems. This first lesson requires students to record their prior knowledge; they will be asked to refer to, reflect on, and revise it throughout the course of the unit.

STCMS has the core ingredients of an effective NGSS-based science curriculum. It is built on the lineage of a proven, research-based program; it is designed to engage students in three-dimensional learning; it elicits and leverages students' prior knowledge of phenomena; it requires students to conduct experiential investigations of that phenomena; and it uses varied methods of formative and summative assessment throughout the unit.