STC
SCIENCE AND TECHNOLOGY CONCEPTS™
MIDDLE SCHOOL

About STC Middle School

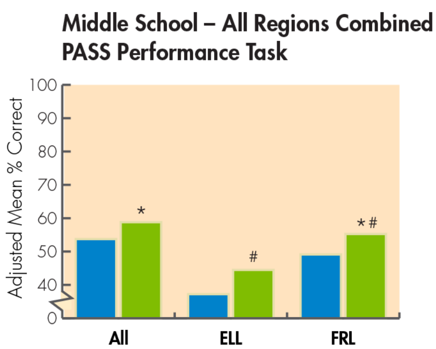
Science and Technology Concepts™ Middle School (STCMS) is a hands-on, inquiry-centered, research-based curriculum proven to raise test scores in science, math, and reading and to close the achievement gap among English language learners and economically disadvantaged students. Each of the program's nine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

- **Teacher Edition**, which includes preparation and procedural information to facilitate instruction; supporting information on the design approach to align the curriculum to NGSS; implementation and differentiation strategies to ensure instruction is accessible for all students; and a description of the assessment system of STCMS.
- **Student Guides**, durable student books that include procedural instructions for the lessons and investigations, as well as the *Building Your Knowledge* and *Extending Your Knowledge* reading selections that extend students' understanding of the phenomena and concepts being studied.
- **Laboratory equipment** needed to conduct the investigations. This provides middle school students with immersive, experiential learning in which they have multiple opportunities to observe and interact with phenomena being investigated.
- Access through Carolina Science Online® and the Smithsonian Science Education Center's website to **online digital resources**, including videos and simulations, that allow experience with and observation of phenomena and/or problems that are not easily accessible in the classroom.

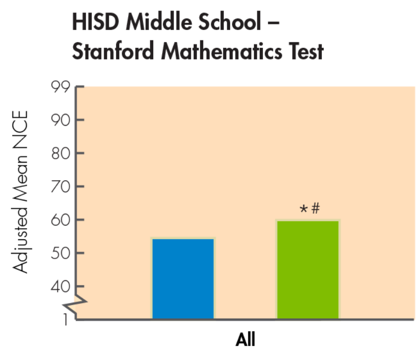
STCMS Improves Student Achievement

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.

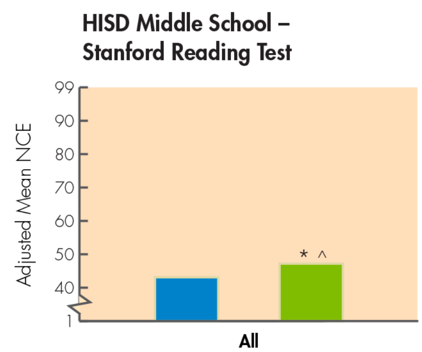
Science Scores Increased



Math Scores Increased



Reading Scores Increased



* statistically significant results

educationally meaningful results

LASER group

Comparison group

STCMS Program Development

The development of STCMS stemmed from the organization of the performance expectations and learning progressions in the Framework and NGSS. Topics for each unit were determined by sorting these performance expectations into related "bundles" from which coherent storylines could be built. This process required an extensive and careful review of the Framework and NGSS. The resulting storylines drove the organization of each unit. The goals were for the curriculum to:

- include all the science and engineering domains;
- cover all middle school performance expectations;
- distribute the performance expectations among grade levels to group content into coherent unit storylines;
- integrate science and engineering practices and crosscutting concepts throughout the curriculum beyond those associated with performance expectations; and
- engage students in authentic, practice-based science.

Concept Storyline

Ecosystems and Their Interactions

Concept Storyline

Unit Driving Question: How do organisms interact with one another and their environments?

Lesson 1: *Pre-Assessment: Ecosystems and Their Interactions*

Focus Question: What do you already know about ecosystems and their interactions?

Students perform short, simple investigations that evaluate their existing knowledge of one or more concepts related to ecosystems and the interactions that occur within them. Students engineer a model pond that they will use throughout the unit to investigate different aspects of ecosystems. Students also create concept maps and KWL charts to explore their existing knowledge.

Lesson 2: *Ecosystem Organization*

Focus Question: How are ecosystems organized?

Students investigate the organization of ecosystems and begin laying the framework for further studies of ecosystems. They begin learning about engineering and its relationship to ecology as they discuss the criteria and constraints that would have to be met to create an artificial habitat for an organism. Students conclude the lesson by applying their understanding of ecosystem organization to their model pond ecosystem.

Lesson 3: *Resources*

Focus Question: How does the availability of resources affect a population of organisms?

Students design and carry out an investigation to determine how the availability of resources affects plant growth, and they extrapolate that to the environment. Students also analyze data based on a model of an ecosystem showing carrying capacity. In the final investigation of the lesson, students consider the resources available in their pond. Then, they apply their understanding of resources to their model pond ecosystem.

Lesson 4: *Matter Cycles*

Focus Question: How do organisms get matter to grow and repair their bodies?

After reading about the movement of water in the ecosystem, students design a model to show the movement of water in an ecosystem. Then, they conduct an experiment using algae and yeast and construct an explanation for the flow of carbon in an ecosystem. Students also take the role of a nitrogen atom as they model the flow of nitrogen through an ecosystem. Based on the information gathered in this lesson and the data they have collected from their pond, students explain how matter is flowing through their model pond.

Lesson 5: *Energy Flow*

Focus Question: How do organisms get energy to live and grow?

Students create a model to show the flow of energy through an African savanna ecosystem. Students also explore the phenomenon of more prey than predators, view a physical demonstration of energy transfer, and model energy transfer across different trophic levels. Through these models, students should develop an understanding of energy transfer, trophic levels, food chains, and food webs. The lesson concludes as students use the data they have collected about their model pond to construct food chains for the organisms in the pond.

Lesson 6: *Organism Interactions*

Focus Question: How do organisms interact with one another?

Students model predation through a simulation. Then, students view videos showing different types of competition. They create their own models of competition based on their experiences. They also analyze presented information about organisms to determine patterns in the relationships that exist between different sets of organisms. Students begin to ask questions that will be answered in a later lesson on natural selection. Using their model pond, students cite evidence to identify relationships that exist between different organisms.

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Lesson 7: *Population Changes*

Focus Question: How do changes to the physical or biological components of an ecosystem affect a population?

Students continue to explore how changes to an ecosystem can affect the populations of organisms that live within it. Students plan and carry out an investigation to determine how changing one aspect of their model pond impacts the populations found there. They also model the introduction of a nonnative species to an ecosystem and explore the patterns of characteristics common to invasive species. Students also examine the different types of succession that occur in an ecosystem and consider the importance of natural disturbances.

Lesson 8: *Natural Selection*

Focus Question: How does natural selection change a population over time?

Students construct explanations about the importance of variation in a population after conducting several investigations on natural selection. Students examine sunflower seeds to observe the variation that occurs between organisms in an ecosystem. Next, they design a simulation in which they model beak and food types of various birds, and then they determine what would occur if a change were to happen in their ecosystem. Students also explore natural selection in a population due to variable survival through two different simulations, one physical and one digital. They again revisit their pond and discuss how changing conditions can lead to selection within their model.

Lesson 9: *Biodiversity*

Focus Question: What is biodiversity and why is it important?

Students model ways in which scientists measure biodiversity and then use mathematics to approximate the number of organisms in their ecosystem. Students explore ecological engineering as they obtain, evaluate, and communicate information about the reintroduction of a species. They engage in argument from evidence as they determine whether a species should be reintroduced to an area in which it no longer exists. Students use their newly learned techniques for measuring biodiversity to communicate how they would measure the biodiversity in their model pond.

Lesson 10: *Human Impact*

Focus Question: How can human impact on the environment be monitored and minimized?

Students plan and carry out an investigation to determine how human activities affect plant growth. They also research the impact that a human activity is having on the ecosystem and create a plan to monitor that human impact. Students also take a final look at their model pond and predict what human activities could impact a natural pond.

Lesson 11: *Assessment: Ecosystems and Their Interactions*

Focus Question: What have you learned about ecosystems and their interactions?

This unit concludes with a two-part assessment. The first part is a Performance Assessment, in which students apply the knowledge and skills they have acquired during the unit to obtain, evaluate, and communicate information about an ecosystem's services. Students are presented with an ecosystem service and must explore threats to the ecosystem service. Then, student groups design a solution to the problem. In the second part, students complete a Written Assessment that covers the performance expectations, disciplinary core ideas, crosscutting concepts, and science and engineering practices incorporated in this unit.

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

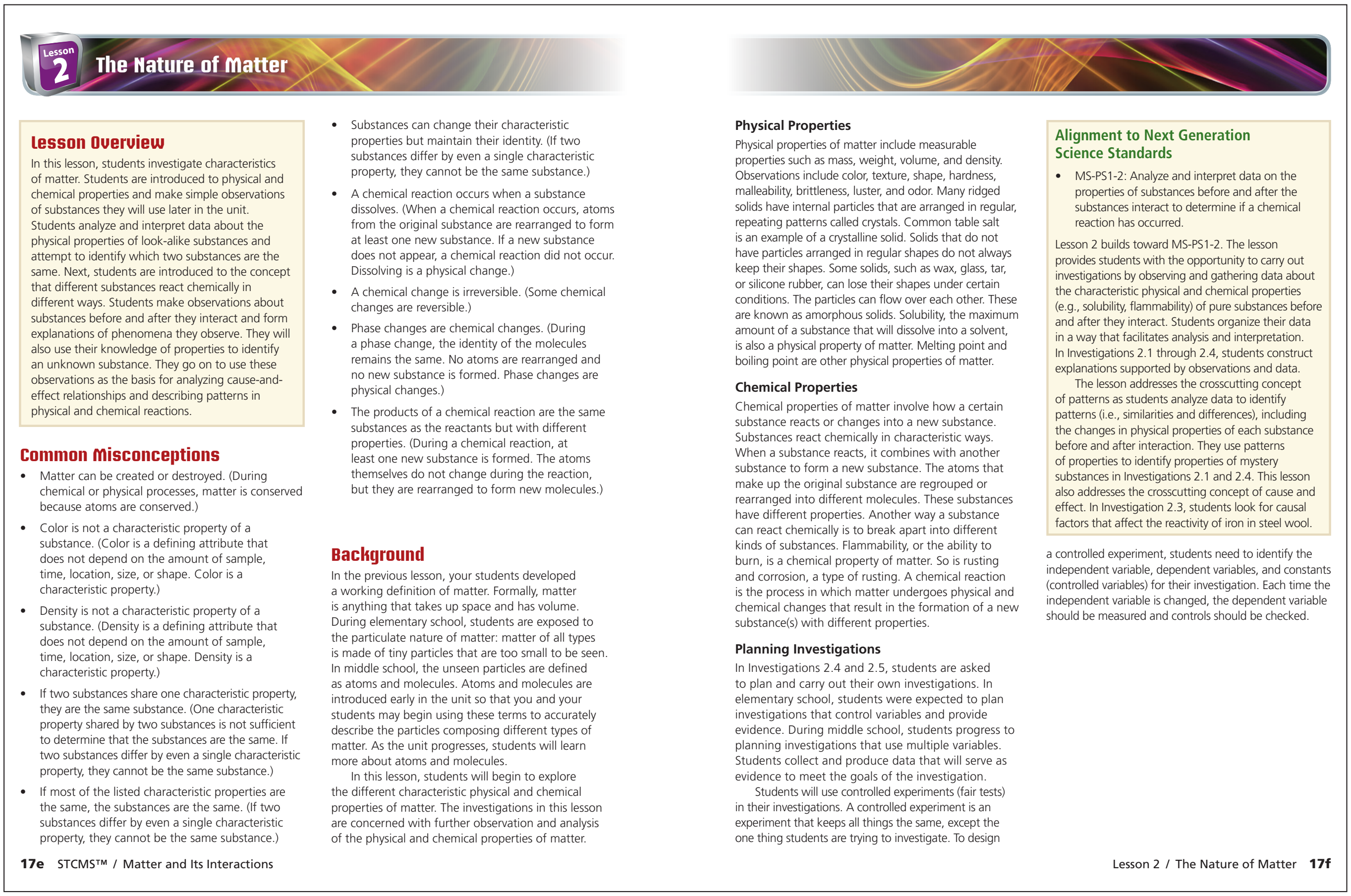
10 STCMS™ / Ecosystems and Their Interactions

Tab 1 / Unit Overview and Lesson Planner 11

Each storyline was aligned to a set of performance expectations based on disciplinary core ideas and learning progressions; this alignment determined which crosscutting concepts and engineering practices would be addressed within a unit. In addition, careful consideration was given to the progression of crosscutting concepts and science and engineering practices over the course of a unit. This resulted in the integration of three-dimensional learning to build toward understanding of the targeted performance expectations.

STCMS Resources for Teacher Planning

The Teacher Edition for each STCMS unit supports the teacher in planning and implementing the curriculum. Tab 1: Unit Overview and Lesson Planner is an overview of the unit as a whole and details how the unit meets the NGSS and integrates the three dimensions. Features of Tab 1 include a list of the unit's targeted NGSS performance expectations; a detailed lesson-by-lesson overview of the unit; a concept storyline that identifies the question that drives the unit's learning progression and summarizes the three dimensions of learning in each lesson; and a suggested pacing guide.



Lesson 2 The Nature of Matter

Lesson Overview

In this lesson, students investigate characteristics of matter. Students are introduced to physical and chemical properties and make simple observations of substances they will use later in the unit. Students analyze and interpret data about the physical properties of look-alike substances and attempt to identify which two substances are the same. Next, students are introduced to the concept that different substances react chemically in different ways. Students make observations about substances before and after they interact and form explanations of phenomena they observe. They will also use their knowledge of properties to identify an unknown substance. They go on to use these observations as the basis for analyzing cause-and-effect relationships and describing patterns in physical and chemical reactions.

Common Misconceptions

- Matter can be created or destroyed. (During chemical or physical processes, matter is conserved because atoms are conserved.)
- Color is not a characteristic property of a substance. (Color is a defining attribute that does not depend on the amount of sample, time, location, size, or shape. Color is a characteristic property.)
- Density is not a characteristic property of a substance. (Density is a defining attribute that does not depend on the amount of sample, time, location, size, or shape. Density is a characteristic property.)
- If two substances share one characteristic property, they are the same substance. (One characteristic property shared by two substances is not sufficient to determine that the substances are the same. If two substances differ by even a single characteristic property, they cannot be the same substance.)
- If most of the listed characteristic properties are the same, the substances are the same. (If two substances differ by even a single characteristic property, they cannot be the same substance.)
- Substances can change their characteristic properties but maintain their identity. (If two substances differ by even a single characteristic property, they cannot be the same substance.)
- A chemical reaction occurs when a substance dissolves. (When a chemical reaction occurs, atoms from the original substance are rearranged to form at least one new substance. If a new substance does not appear, a chemical reaction did not occur. Dissolving is a physical change.)
- A chemical change is irreversible. (Some chemical changes are reversible.)
- Phase changes are chemical changes. (During a phase change, the identity of the molecules remains the same. No atoms are rearranged and no new substance is formed. Phase changes are physical changes.)
- The products of a chemical reaction are the same substances as the reactants but with different properties. (During a chemical reaction, at least one new substance is formed. The atoms themselves do not change during the reaction, but they are rearranged to form new molecules.)

Background

In the previous lesson, your students developed a working definition of matter. Formally, matter is anything that takes up space and has volume. During elementary school, students are exposed to the particulate nature of matter: matter of all types is made of tiny particles that are too small to be seen. In middle school, the unseen particles are defined as atoms and molecules. Atoms and molecules are introduced early in the unit so that you and your students may begin using these terms to accurately describe the particles composing different types of matter. As the unit progresses, students will learn more about atoms and molecules.

In this lesson, students will begin to explore the different characteristic physical and chemical properties of matter. The investigations in this lesson are concerned with further observation and analysis of the physical and chemical properties of matter.

Physical Properties

Physical properties of matter include measurable properties such as mass, weight, volume, and density. Observations include color, texture, shape, hardness, malleability, brittleness, luster, and odor. Many ridged solids have internal particles that are arranged in regular, repeating patterns called crystals. Common table salt is an example of a crystalline solid. Solids that do not have particles arranged in regular shapes do not always keep their shapes. Some solids, such as wax, glass, tar, or silicone rubber, can lose their shapes under certain conditions. The particles can flow over each other. These are known as amorphous solids. Solubility, the maximum amount of a substance that will dissolve into a solvent, is also a physical property of matter. Melting point and boiling point are other physical properties of matter.

Chemical Properties

Chemical properties of matter involve how a certain substance reacts or changes into a new substance. Substances react chemically in characteristic ways. When a substance reacts, it combines with another substance to form a new substance. The atoms that make up the original substance are regrouped or rearranged into different molecules. These substances have different properties. Another way a substance can react chemically is to break apart into different kinds of substances. Flammability, or the ability to burn, is a chemical property of matter. So is rusting and corrosion, a type of rusting. A chemical reaction is the process in which matter undergoes physical and chemical changes that result in the formation of a new substance(s) with different properties.

Planning Investigations

In Investigations 2.4 and 2.5, students are asked to plan and carry out their own investigations. In elementary school, students were expected to plan investigations that control variables and provide evidence. During middle school, students progress to planning investigations that use multiple variables. Students collect and produce data that will serve as evidence to meet the goals of the investigation.

Students will use controlled experiments (fair tests) in their investigations. A controlled experiment is an experiment that keeps all things the same, except the one thing students are trying to investigate. To design a controlled experiment, students need to identify the independent variable, dependent variables, and constants (controlled variables) for their investigation. Each time the independent variable is changed, the dependent variable should be measured and controls should be checked.

Alignment to Next Generation Science Standards

- 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.

Lesson 2 builds toward MS-PS1-2. The lesson provides students with the opportunity to carry out investigations by observing and gathering data about the characteristic physical and chemical properties (e.g., solubility, flammability) of pure substances before and after they interact. Students organize their data in a way that facilitates analysis and interpretation. In Investigations 2.1 through 2.4, students construct explanations supported by observations and data.

The lesson addresses the crosscutting concept of patterns as students analyze data to identify patterns (i.e., similarities and differences), including the changes in physical properties of each substance before and after interaction. They use patterns of properties to identify properties of mystery substances in Investigations 2.1 and 2.4. This lesson also addresses the crosscutting concept of cause and effect. In Investigation 2.3, students look for causal factors that affect the reactivity of iron in steel wool.

17e STCMS™ / Matter and Its Interactions

Lesson 2 / The Nature of Matter 17f

In Tab 6: Unit Investigations, the beginning of each lesson provides specific details to support the teacher in implementation. The opening of every lesson features a chart that provides overview information about each part of the lesson, including objectives, concepts, key terms, estimated class time, NGSS standards, and an assessment strategy. After that is a detailed lesson overview, which ties the lesson objectives to previous and future learning in the unit; identifies common misconceptions that students may have regarding the lesson content; and provides science content background information for the teacher. This section also highlights alignment to NGSS information, detailing the performance expectations that the lesson addresses and how the lesson investigations integrate disciplinary core ideas, science and engineering practices, and crosscutting concepts.

Other features that support teachers in implementation include in-depth preparation and setup instructions, and teacher investigation instructions that include images of student pages. Taken together, these features provide teachers with the information necessary to guide all students to success using STCMS.

STCMS has the core ingredients of an effective NGSS-based science curriculum. The curriculum was designed with careful consideration of the progression of the three dimensions to support student sensemaking of the units' selected performance expectations. Developers built thematic units along strong conceptual storylines and employed effective research-based science pedagogy to create experiential, hands-on investigations of phenomena. Building in the effective supports to enable teachers to successfully implement the curriculum was a necessary component to ensure that the curriculum reaches all students. These elements, when viewed together as a complete curriculum, make STCMS the right choice for teaching middle school science.