NGSS Connections

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It's a Gassy World!
Grade Level: Middle School

Performance Expectations: Students' ability to complete the following performance expectation(s) will be supported by participation in this activity.

MS-ESS3-3: Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
MS-ESS3-4: Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.
MS-ESS3-5: Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.
MS-PS1-4: Develop a model that predicts and describes the changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.

Dimension	NGSS Code or citation	Corresponding student task in activity
Disciplinary Core Idea	ESS2.D Weather and Climate • Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. • Greenhouse gases in the atmosphere absorb and retain the energy radiated from land and ocean surfaces, thereby regulating Earth's average temperature and keeping it habitable.	Students answer the question of how the climate will change as the ocean absorbs less carbon dioxide and the atmosphere holds more carbon dioxide. Students identify CO_2 as a greenhouse gas, and they discuss its role in absorbing and retaining heat (energy), which is necessary for keeping Earth habitable. They also discuss that too much CO_2 in the atmosphere is increasing the Earth's temperature.
	ESS3.C Human Impacts on Earth Systems • Human impacts have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of many other species. But changes to the Earth's environments can	Students describe how human activities (i.e., burning fossil fuels) have contributed to more CO_2 in the atmosphere than previously.

	have different impacts (negative and positive) for different living things. • Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth, unless the activities and technologies involved are engineered otherwise.	Students identify ways people can reduce CO_2 emissions, and ways that they, themselves, can help offset their CO_2 emissions.
	ESS3.D Global Climate Change • Human activities, such as the release of greenhouse gas emissions from burning fossil fuels, are major factors in the current rise in Earth's mean surface temperature (global warming). Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior and on applying that knowledge wisely in decisions and activities.	Students watch then analyze a video of scientists designing and carrying out a study to determine if CO_2 retains heat and changes temperatures. Students identify ways people can reduce CO_2 emissions, and ways that they, themselves, can help offset their CO_2 emissions.
	PS1.A Structure and Properties of Matter • Gases and liquids are made of molecules of inert atoms that are moving about relative to each other. In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide.	Students study the kinetic molecular theory and apply it to their investigations to explain why warmer oceans will not hold as much CO_2 as compared to colder oceans.
Practice	Asking Questions and Defining Problems • Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information. • Ask questions to determine relationships between independent and dependent variables and relationships in models.	During lab, students are asked to explain why one balloon is larger than the other, and to identify which temperature of water is holding the most CO_2, as indicated by the relative balloon size. Students ask questions to determine why the warmer salt water's balloon is larger than the colder salt water's

	• Ask questions to identify and/or clarify evidence and/or the premise of an argument. • Ask questions that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles.	balloon, and to make the connection between the independent and dependent variables. Students write their hypotheses for the investigation they design to answer the driving question, *Will warmer or colder oceans hold more carbon dioxide?*
	Developing and Using Models • Use and/or develop a model of simple systems with uncertain and less predictable factors. • Develop and/or use a model to predict and/or describe phenomena. • Develop and/or use a model to generate data to test ideas about phenomena in natural or designed systems, including those representing inputs and outputs, and those at unobservable scales.	Students develop then use a model to test whether warmer oceans will retain more, less, or the same amount of carbon dioxide as compared to colder oceans. Students use the data collected by their models to support or reject their hypotheses regarding the impacts of warmer ocean temperatures on carbon dioxide retention.
	Planning and Carrying out Investigations • Plan an investigation individually and collaboratively and in the design identify independent and dependent variables and controls, what tools are need to do the gathering, how measurements will be recorded, and how many data are need to support a claim. • Conduct an investigation and/or evaluate and/or revise the experimental design to produce data to serve as the basis for evidence that meet the goals of the investigation. • Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions.	Students design their investigation and how to use their models to answer the driving question, *Will warmer or colder oceans hold more carbon dioxide?* Students evaluate and revise their experimental design according to their experiences in the lab and in response to peer reviews and/or instructor questions. Students collect data using their investigation protocols and their models in order to test their hypotheses.
	Analyzing and Interpreting Data	Students use data collected in their investigations to construct a graph of the data, and to interpret that

	• Construct, analyze, and/or interpret graphical displays of data and/or large data sets to identify linear and nonlinear relationships. • Analyze and interpret data to provide evidence for phenomena. • Consider limitations of data analysis (e.g., measurement error), and/or seek to improve precision and accuracy of data with better technological tools and methods (e.g., multiple trials).	graph to understand which water temperature held the most carbon dioxide. Students consider the number of trials necessary for their investigation's accuracy. Student also answer the question of how to collect the data.
	Construction Explanations and Designing Solutions • Construct an explanation using models or representations. • Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. • Apply scientific ideas, principles, and/or evidence to construct, revise and/or use an explanation for realworld phenomena, examples, or events. • Apply scientific reasoning to show why the data or evidence is adequate for the explanation or conclusion.	Students use their models and data collected to explain the impact of warmer ocean temperatures on carbon dioxide retention and subsequently atmospheric carbon dioxide levels. Students use the kinetic molecular theory to explain why their data supports their claims regarding ocean temperature and carbon dioxide retention. This is completed using a Claim-Evidence-Reasoning framework.
Crosscutting Concept	Cause and Effect • Cause and effect relationships may be used to predict phenomena in natural or designed systems.	Students use the cause and effect relationships of warmer oceans retaining less carbon dioxide to predict continued increases in the average global temperature.
	Systems and System Models • Models can be used to represent systems and their interactions—such as inputs, processes and outputs—	Students build a model of the different temperatures of ocean water and carbon dioxide absorption. They recognize that these models are limited because they

	and energy, matter, and information flows within systems. • Models are limited in that they only represent certain aspects of the system under study.	are simple and do not contain all of the factors involved in controlling carbon dioxide in the atmosphere.
	Stability and Change of Systems • Systems in dynamic equilibrium are stable due to a balance of feedback mechanisms.	Students study positive feedback systems and apply them to carbon dioxide concentrations in the ocean and atmosphere and the relationship to global temperatures. They describe that they system if not in equilibrium because more CO_2 in the atmosphere leads to higher global temperatures, which leads to more CO_2 released from the oceans and even higher temperatures.

Nature of Science

Scientific Investigations Use a Variety of Methods

- Science investigations use a variety of methods and tools to make measurements and observations.

Scientific Knowledge Assumes an Order and Consistency in Natural Systems

- Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurements and observation.

Scientific Knowledge is Based on Empirical Evidence

- Science knowledge is based upon logical and conceptual connections between evidence and explanations.

Science is a Way of Knowing

- Science is both a body of knowledge and the processes and practices used to add to that body of knowledge.
- Science knowledge is cumulative and many people, from many generations and nations, have contributed to science knowledge.

Science is a Human Endeavor

- Men and women from different social, cultural, and ethnic backgrounds work as scientists and engineers.

Connections to Common Core State Standards

English Language Arts/Literacy	Mathematics
RST.6-8.3	6.SP.4
RST.6-8.4	6.SP.5
RST.6-8.7	7.RP.A.2

W.6-8.1	