[1]Big Idea 1- Description

A: Scientific inquiry is a multifaceted activity; The processes of science include the formulation of scientifically investigable questions, construction of investigations into those questions, the collection of appropriate data, the evaluation of the meaning of those data, and the communication of this evaluation.

B: The processes of science frequently do not correspond to the traditional portrayal of "the scientific method."

C: Scientific argumentation is a necessary part of scientific inquiry and plays an important role in the generation and validation of scientific knowledge.

D: Scientific knowledge is based on observation and inference; it is important to recognize that these are very different things. Not only does science require creativity in its methods and processes, but also in its questions and explanations.

Big Idea 1- Benchmarks- Grade 6

- **SC.6.N.1.1:** Define a problem from the sixth grade curriculum, use appropriate reference materials to support scientific understanding, plan and carry out scientific investigation of various types, such as systematic observations or experiments, identify variables, collect and organize data, interpret data in charts, tables, and graphics, analyze information, make predictions, and defend conclusions.
- **SC.6.N.1.2:** Explain why scientific investigations should be replicable.
- **SC.6.N.1.3:** Explain the difference between an experiment and other types of scientific investigation, and explain the relative benefits and limitations of each.
- **SC.6.N.1.4:** Discuss, compare, and negotiate methods used, results obtained, and explanations among groups of students conducting the same investigation.
- **SC.6.N.1.5:** Recognize that science involves creativity, not just in designing experiments, but also in creating explanations that fit evidence.

Big Idea 1- Benchmarks- Grade 7

- **SC.7.N.1.1:** Define a problem from the seventh grade curriculum, use appropriate reference materials to support scientific understanding, plan and carry out scientific investigation of various types, such as systematic observations or experiments, identify

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variables, collect and organize data, interpret data in charts, tables, and graphics, analyze information, make predictions, and defend conclusions.

- **SC.7.N.1.2:** Differentiate replication (by others) from repetition (multiple trials).
- **SC.7.N.1.3:** Distinguish between an experiment (which must involve the identification and control of variables) and other forms of scientific investigation and explain that not all scientific knowledge is derived from experimentation.
- **SC.7.N.1.4:** Identify test variables (independent variables) and outcome variables (dependent variables) in an experiment.
- **SC.7.N.1.5:** Describe the methods used in the pursuit of a scientific explanation as seen in different fields of science such as biology, geology, and physics.
- **SC.7.N.1.6:** Explain that empirical evidence is the cumulative body of observations of a natural phenomenon on which scientific explanations are based.
- **SC.7.N.1.7:** Explain that scientific knowledge is the result of a great deal of debate and confirmation within the science community.

Big Idea 1- Benchmarks- Grade 8

- **SC.8.N.1.1:** Define a problem from the eighth grade curriculum using appropriate reference materials to support scientific understanding, plan and carry out scientific investigations of various types, such as systematic observations or experiments, identify variables, collect and organize data, interpret data in charts, tables, and graphics, analyze information, make predictions, and defend conclusions.
- **SC.8.N.1.2:** Design and conduct a study using repeated trials and replication.
- **SC.8.N.1.3:** Use phrases such as "results support" or "fail to support" in science, understanding that science does not offer conclusive 'proof' of a knowledge claim.
- **SC.8.N.1.4:** Explain how hypotheses are valuable if they lead to further investigations, even if they turn out not to be supported by the data.
- **SC.8.N.1.5:** Analyze the methods used to develop a scientific explanation as seen in different fields of science.
- **SC.8.N.1.6:** Understand that scientific investigations involve the collection of relevant empirical evidence, the use of logical reasoning, and the application of imagination in devising hypotheses, predictions, explanations and models to make sense of the collected evidence.

How do scientists learn new things about the natural world?

Scientists observe things that happen and look for details. When a scientist observes something in nature, the information is carefully recorded so it can be studied later in order to look for patterns. When a scientist conducts an experiment, it is carefully planned out in

advance. The tests follow a specific order. Again, the data is carefully collected so that it can be studied later in order to look for patterns.

To gain a depth of understanding of the process of scientific investigation, students need to design and practice completing investigations. At the highest level of understanding, students are able to critique others' investigations and results. *DE Science Techbook* contains resources in the Process Skills Library that help students to develop science investigations, first virtually, then hands-on with the goal of moving students to independence in posing and answering their own testable questions through investigation. It also provides them with opportunities to observe and critique other investigations.

Virtual Labs focus on a topic and provide a limited set of variables from which students can choose when learning to design their own investigations. Students are required to plan the investigation and have the design approved before they conduct the investigation. They must collect data, analyze the data, and draw a conclusion based on that data. They report the results to others. Each Virtual Lab is paralleled by a Hands-on Lab, so that students repeat a similar or related procedure in a hands-on environment. Multiple Virtual Labs and Hands-On Labs are included at each grade level so that practice occurs across many science topics.

Specially edited *Mythbusters* episodes increase student understanding of investigative design. These resources include observation sheets that enable students to become peer reviewers of a science investigation—questioning the quality of the design, how well it was conducted, and whether or not the conclusion was valid. In a different resource, *Science Sleuths* investigations challenge students to apply their science skills to solving mysteries. Students conduct video interviews, read through documents, watch video, and conduct tests to gather data that will help them develop solutions.

- **Scientific observation**: Scientists use observation as part of their investigations. They carefully record everything they observe, including the smallest details. Scientists use all of the senses, i.e., seeing, hearing, feeling, smelling, and sometimes tasting, as well as their sense of balance. They also use such special tools as microscopes and telescopes that are made just for investigating. Many scientists use devices that allow them to sense things that human senses cannot. For example, a seismologist uses a seismograph to sense earthquakes happening far away under the Earth's surface. A marine biologist may use a sensitive microphone to hear and record the sounds dolphins make at a range that humans cannot hear.

- **Identifying variables**: Scientists identify and control variables in an investigation to find out why things happen. For example, if a plant isn't growing, what could be causing the

problem? Is it the amount of light? The amount of moisture? The soil? All of these are variables that a scientist would test. Scientists typically change only one variable at a time. If the amount of light is being tested, then the soil type and the amount of water have to be kept the same. If more than one variable is changed, and the plant grows differently, then we won't know which variable caused the change and the test must be run again. Scientists will run multiple tests, changing the same variable each time. If they want to test a second variable, they run a second series of tests, changing only that variable and keeping the others the same.

- **Collecting and organizing data**: As scientists conduct investigations, they are careful to record their observations and the results of any changes that they make. Scientists use tables to organize data. They sketch images or take pictures to record changes. They often graph data that they collect to compare numbers and changes in things over time.

- **Analyzing data and interpreting data**: When scientists complete their observations and investigations, they have a lot of data to work with. *Which rocks that were collected contained bits of quartz? What variable most affected the distance traveled by a model rocket?* Scientists often put data into tables and graphs to look for patterns and to see how much change has taken place over time.

- **Making hypotheses**: Scientists often try to figure out how something happens. For example, *What substance added to water would cause the water to stay liquid at a temperature lower than 0 ^{o} Celsius (32 ^{o} Fahrenheit)?* There are many variables to test. Scientists use personal background knowledge to decide what to try first. For example, a scientist might notice that seawater can get colder than *0 ^{o} Celsius* and still stay liquid. Seawater is salty, so the hypothesis might be that salt added to water can lower its freezing point.

- **Defending conclusions**: Scientists draw a conclusion based on the evidence found in an investigation. In a field study, scientists use data they collect to find a pattern. Such a pattern might be what time of day a particular animal feeds? In an experiment, scientists change a variable and find out what happens. They might collect data on how air temperature affects an animal's movement. Their conclusions are based on the data. If anyone asks, *Why do you think that's so?* scientists can share the data as evidence.

Why should scientific investigations be replicable?

During the scientific process, data is collected and analyzed, and conclusions are formed about hypotheses. What separates science from other areas of investigation is that in order for

scientific processes to be considered valid, the investigation must be able to be replicated. When scientists say *replicable*, they are saying that the investigation must be able to be repeated by someone else under the same circumstances. Without an investigation being replicable, no one can verify the results.

How are creativity and science connected?

Often during a scientific investigation, scientists must use a certain amount of creativity. In some cases what the scientist wants to study requires a new piece of lab equipment or a new procedural design. Without the scientist taking a creative approach to solving these issues, the entire investigation might not be able to be conducted. This creativity is not only limited to the design of the investigation. Sometimes the results that are obtained from an investigation don't fit the most logical explanation. Scientists then need to think creatively in order to form an explanation for their results.

Glossary Terms

- observe
- microscope
- telescope
- data
- variable
- independent variable
- dependent variable
- fair test
- range
- design
- analyze
- forecast
- evidence
- hypothesis
- experiment
- conclusion
- inference
- verify
- investigate
- scientific method

Instructional Ideas

1. Have students read the content in the section *How do scientists learn new things about the natural world?* Review the glossary terms with students to clarify their prior knowledge.
2. Use a jigsaw approach and have students work in groups to compare and contrast the following pairs of terms: *dependent variable-independent variable, observation-inference, analysis-conclusion, and experiment-scientific method*. A Venn diagram is a good graphic organizer for students to use.
3. Have the student groups report out their comparisons for each pair of terms and record these answers on a class chart in the front of the room.

4. Have students complete the **Crime Scene Investigation** Integrated Science Simulation. Students will practice using science process skills.
5. Ask students to identify the skills that they used during the simulation (i.e., observation, inference, data, analyze, conclusion).
6. Have students read the sections *Why should scientific investigations be replicable?* and *How are creativity and science connected?*
7. After students complete the reading, have them watch Mythbusters: Inertia: The Helium Football While they watch, have them do a peer review of the *MythBusters* using the **Student Peer Review Sheet**.
8. Have students share their peer reviews with partners.
9. Have the student partners report their findings to the class.