Related Standards and Background Information

Scientific Investigation, Reasoning, and Logic

This strand represents a set of systematic inquiry skills that defines what a student will be able to do when conducting activities and investigations, and represents the student understanding of the nature of science. The various skill categories are described in the ―Investigate and Understand‖ section of the Introduction to the *Science Standards of Learning*, and the skills in science standard 5.1 represent more specifically what a student should be able to do as a result of science experiences in fifth grade. Across the grade levels, the skills in the ―Scientific Investigation, Reasoning, and Logic‖ strand form a nearly continuous sequence of investigative skills and an understanding of the nature of science. It is important that the classroom teacher understand how the skills in standard 5.1 are a key part of this sequence (i.e., K.1, K.2, 1.1, 2.1, 3.1, 4.1, 5.1, and 6.1). The fifth-grade curriculum should ensure that skills from preceding grades are continuously reinforced and developed

5.1 The student will demonstrate an understanding of scientific reasoning, logic, and the nature of science by planning and conducting investigations in which

a) items such as rocks, minerals, and organisms are identified using various classification keys;
b) estimates are made and accurate measurements of length, mass, volume, and temperature are made in metric units using proper tools;
c) estimates are made and accurate measurements of elapsed time are made using proper tools;
d) hypotheses are formed from testable questions;
e) independent and dependent variables are identified;
f) constants in an experimental situation are identified;
g) data are collected, recorded, analyzed, and communicated using proper graphical representations and metric measurements;
h) predictions are made using patterns from data collected, and simple graphical data are generated;
i) inferences are made and conclusions are drawn;
j) models are constructed to clarify explanations, demonstrate relationships, and solve needs; and
k) current applications are used to reinforce science concepts.

Understanding the Standard: Scientific Investigation

The skills in standard 5.1 are intended to define the "investigate" component and the understanding of the nature of science for all of the other fifth-grade standards (5.2–5.7). The intent of standard 5.1 is for students to continue to develop a range of inquiry skills, achieve proficiency with those skills, and develop and reinforce their understanding of the nature of science in the context of the concepts developed at the fifth-grade level. **Standard 5.1 does not require a discrete unit be taught on scientific investigation because the skills that make up the standard should be incorporated in all the other fifth-grade standards.** It is also intended that by developing these skills, students will achieve a greater understanding of scientific inquiry and the nature of science and will more fully grasp the content-related concepts.

Overview	Essential Knowledge, Skills and Processes
• The nature of science refers to the foundational concepts that govern the way scientists formulate explanations about the natural world. The nature of science includes the following concepts: a) the natural world is understandable; b) science is based on evidence, both observational and experimental; c) science is a blend of logic and innovation; d) scientific ideas are durable yet subject to change as new data are collected; e) science is a complex social endeavor; and f) scientists try to remain objective and engage in peer review to help avoid bias. In grade five, an emphasis should be placed on concepts a, b, c, d, and e. • Science assumes that the natural world is understandable. Scientific inquiry can provide explanations about nature. This expands students' thinking from just a knowledge of facts to understanding how facts are relevant to everyday life. • Science demands evidence. Scientists develop their ideas based on evidence and they change their ideas when new evidence becomes available or the old evidence is viewed in a different way. • Science uses both logic and innovation. Innovation has always been an important part of science. Scientists draw upon their creativity to visualize how nature works, using analogies, metaphors, and mathematics. • Scientific ideas are durable yet subject to change as new data are collected. The main body of scientific knowledge is very stable and grows by being corrected slowly and having its boundaries extended gradually. Scientists themselves accept the notion that scientific knowledge is always open to improvement and can never be declared absolutely certain. New questions arise, new theories are proposed, new instruments are invented, and new techniques are developed. • Science is a complex social endeavor. It is a	In order to meet this standard, it is expected that students will • use classification keys to identify rocks, minerals, and organisms. • select and use the appropriate instruments, including centimeter rulers, meter sticks, graduated cylinders, balances, stopwatches, and thermometers for making basic measurements. • make reasonable estimations of length, mass, volume, and elapsed time. • measure length, mass, volume, and temperature using metric measures. This includes millimeters, centimeters, meters, kilometers, grams, kilograms, milliliters, liters, and degrees Celsius. • use a testable question to form a hypothesis as cause and effect (e.g., "if…, then…") statement. • analyze the variables in a simple experiment and identify the independent and dependent variables, and the constants. • collect, record, analyze, and report data, using charts and tables, and translate numerical data into bar or line graphs. • make predictions based on trends in data. This requires the recognition of patterns and trends and determination of what those trends may represent. • make inferences and draw conclusions. • distinguish between inferences and conclusions. • construct a physical model to clarify an explanation, demonstrate a relationship, or solve a need.

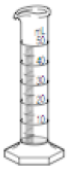
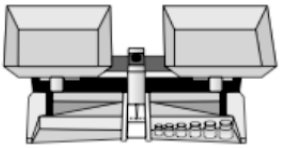
complex social process for producing knowledge about the natural world. Scientific knowledge represents the current consensus among scientists as to what is the best explanation for phenomena in the natural world. This consensus does not arise automatically, since scientists with different backgrounds from all over the world may interpret the same data differently. To build a consensus, scientists communicate their findings to other scientists and attempt to replicate one another's findings. In order to model the work of professional scientists, it is essential for fifth-grade students to engage in frequent discussions with peers about their understanding of their investigations. • Systematic investigations require standard measures and consistent and reliable tools. Metric measures are a standard way to make measurements and are recognized around the world. • A classification key is an important tool used to help identify objects and organisms. It consists of a branching set of choices organized in levels, with most levels of the key having two choices. Each level provides more specific descriptors, eventually leading to identification. • A hypothesis is an educated guess/prediction about what will happen based on what you already know and what you have already learned from your research. It must be worded so that it is "testable." The hypothesis can be written as an "If…, then…." statement, such as "If all light is blocked from a plant for two weeks, then the plant will die." • An independent variable is the factor in an experiment that is altered by the experimenter. The independent variable is purposely changed or manipulated. • A dependent variable is the factor in an experiment that changes as a result of the manipulation of the independent variable. • The constants in an experiment are those things that are purposefully kept the same throughout the experiment. • When conducting experiments, data are collected, recorded, analyzed, and communicated using proper graphical	

representations and metric measurements. • Systematic investigations require organized reporting of data. The way the data are displayed can make it easier to see important patterns, trends, and relationships. Bar graphs and line graphs are useful tools for reporting discrete data and continuous data, respectively. • A scientific prediction is a forecast about what may happen in some future situation. It is based on the application of factual information and principles and recognition of trends and patterns. • Estimation is a useful tool for making approximate measures and giving general descriptions. In order to make reliable estimates, one must have experience using the particular unit. • An inference is a tentative explanation based on background knowledge and available data. • A conclusion is a summary statement based on the results of an investigation. Scientific conclusions are based on verifiable observations (science is empirical). • Scientific modeling is the process of generating abstract, conceptual, graphical and/or mathematical models. It is an approximation or simulation of a real system that omits all but the most essential variables of the system. In order to create a model, a scientist must first make some assumptions about the essential structure and relationships of objects and/or events in the real world. These assumptions are about what is necessary or important to explain the phenomena. • It is important for students to apply the science content that they have learned to current issues and applications.	

Science Vocabulary

analysis - the process of studying results and data to find patterns
balance – a tool used for measuring mass (The units of measure for mass include grams and kilograms.)
conclusion – an opinion or judgment made after some thought and based on evidence
constant – all the factors and materials that remain the same during an experiment
data – information collected during an experiment
dependent variable - the factor in an experiment that changes as a result of the independent variable
elapsed time – the amount of time that has passed from the beginning to the end of an event (measured using seconds, minutes, hours)
experiment - a fair test driven by a hypothesis
graduated cylinder – a tool used for measuring volume (The units of measure for volume include milliliters and liters.)
hypothesis - a prediction about the relationship between variables always written as an "if/then" statement. (If I add more salt to the water, then the temperature will increase.)
independent variable - the one factor in an experiment that is altered by the experimenter
inference – a conclusion based on evidence about events that have already occurred
length - the linear distance between two points (The units of measure for length include millimeters, centimeters, meters, and kilometers.)
mass - the amount of matter in an object (The basic unit of mass is the gram.)
metric ruler or meter stick – a tool used for measuring length (The units of measure for length include millimeters, centimeters, meters, and kilometers.)
observation – the use of senses to collect information about the environment
prediction - a forecast about what may happen in some future situation
repeated trials – doing an experiment multiple times to avoid experimental error
temperature – the amount of heat given off by an object (Temperature is measured in degrees Celsius.)
thermometer –a tool used for measuring temperature (The units of measure for temperature is Celsius.)
unusual results – inconsistent data that suggests an experimental error has occurred
volume - the amount of space taken up by an object (The basic unit of volume is the liter.)

Students must master all of the tools below and be familiar with the bold-faced words associated with them.

Tool	Name	Measures	Units
	Metric Ruler or Meter Stick	Length	Millimeters Centimeters Meters Kilometers
	Graduated Cylinder	Accurate Volume	Liters Milliliters
	Thermometer	Temperature	Celsius
	Double Pan Balance	Mass/Weight	Grams Kilograms
	Stopwatch	Elapsed Time	Hours Minutes Seconds
	Beaker	Volume (does not measure volume accurately, but is used in some ways)	Liters Milliliters