Scientific Inquiry

4-1 The student will demonstrate an understanding of scientific inquiry, including the processes, skills, and mathematical thinking necessary to conduct a simple scientific investigation.

4-1.1 Classify observations as either quantitative or qualitative.
Taxonomy Level: 2.3-B Understand Conceptual Knowledge

Previous/Future knowledge: In kindergarten (K-1.4), students identified observed objects or events using the senses. In 1st grade (1-1.1), students compared, classified, and sequenced objects by number, shape, texture, size, color, and motion, using Standard English units of measurement where appropriate. In 3rd grade, students classified objects by two of their properties (3-1.1) and classified objects or events in sequential order (3-1.2). They will use this skill throughout the remainder of their science instruction.

It is essential for students to know that making *observations* is a way of learning about the world around us.

- A *scientific observation* is one that anyone can make and the result will always be the same. Scientific observations are made by using the senses or taking measurements. For example, the animal is black, has four legs, is 25 cm tall, and feels soft.
- An *unscientific observation*, or an opinion, is one that not everyone may agree on. For example, the dog is happy.
- Observing does not mean just looking at something. It involves the use of several or all of the five senses (seeing, hearing, smelling, touching, and tasting) using appropriate observation methods for each sense, such as wafting an odor so that its smell can be described or gently touching the edges of seashells to determine their textures.
- Tasting in science should only be done with the permission of the teacher under controlled conditions.
- Observing helps to find out about objects (their characteristics, properties, differences, similarities) and events (what comes first or last, or what is happening at a particular moment).

Observations can be classified as quantitative or qualitative.

Quantitative observations are

- Observations that use numbers (amounts) or measurements (including the unit label).
- Observations that make relative comparisons, such as more than, all, less than, few, or none.
- Specific pieces of information that communicate to others and serve as a basis for comparison.

Qualitative observations are

- Observations that are made using only the senses and refer to specific attributes.
- Communicated as words, pictures, or diagrams.

Assessment Guidelines:
The objective of this indicator is to *classify* observations as either quantitative or qualitative; therefore, the primary focus of assessment should be to determine if an observation is qualitative or quantitative based on a given description. However, appropriate assessments should also require students to *recognize* a quantitative or qualitative observation; *compare* quantitative and qualitative observations; *recall* that quantitative measurements must have a unit label; *exemplify* quantitative or qualitative observations; or *summarize* the difference between a qualitative and a quantitative observation.

Scientific Inquiry

4-1 The student will demonstrate an understanding of scientific inquiry, including the processes, skills, and mathematical thinking necessary to conduct a simple scientific investigation.

4-1.2 Use appropriate instruments and tools (including a compass, an anemometer, mirrors, and a prism) safely and accurately when conducting simple investigations
Taxonomy Level: 3.2-B Apply Conceptual Knowledge

Previous/Future knowledge: In previous grades, students used magnifiers and eyedroppers (K-1.2), rulers (1-1.2), thermometers, rain gauges, balances, and measuring cups (2-1.2), and beakers, meter tapes and sticks, forceps/tweezers, tuning forks, graduated cylinders, and graduated syringes (3-1.5) safely, accurately, and appropriately. In future grades, students will continue to use these tools, when appropriate, as well as use new tools when collecting scientific data. A complete list of tools can be found in Appendix A of the Academic Standards.

It is essential for students to know that every simple scientific investigation provides information. This information is called *data*. Data can be qualitative observations or quantitative observations, such as measurements (in metric units or English units when appropriate).

It is essential for students to know that different instruments or tools are needed to collect different kinds of data.

- A *compass* is a tool that is used to determine the cardinal directions of North, South, East, and West when using a wind vane to identify wind direction.
- An *anemometer* is a weather instrument used to determine wind speed.
  - An anemometer should be vertical and needs to be able to spin without obstruction.
  - An anemometer measures wind speed in miles per hour (mph).
- A *mirror* (plane/flat) is a tool that reflects light toward a given direction.
- A *prism* is a tool that breaks light into the colors of the spectrum.
  - To use a prism appropriately, the light has to enter the prism at the correct angle to the surface in order to separate the white light.

It is essential for students to use care when handling these tools when gathering data.

- A compass should not be placed near a magnet.
- Care should be taken not to break or scratch the mirror or prism.

It is also essential for students to use tools from previous grade levels that are appropriate to the content of this grade level such as magnifiers, rulers (measuring to millimeters), measuring cups (measuring in parts of a cup), rain gauges (measuring in inches), thermometers (measuring in ^{o}F and ^{o}C), beakers or graduated cylinders (measuring to milliliters or liters), forceps/tweezers, meter sticks and meter tapes (measuring in meters, centimeters, or millimeters) to gather data. Other units of measurement that students should be familiar with are kilograms (mass) or kilometers (distance).

NOTE TO TEACHER: See information in previous grades regarding how to use each tool.
All temperature readings during investigations will be taken using the Celsius scale unless the data refers to weather when the Fahrenheit scale is used.

Scientific Inquiry

4-1 The student will demonstrate an understanding of scientific inquiry, including the processes, skills, and mathematical thinking necessary to conduct a simple scientific investigation.

It is not essential for students to use concave or convex mirrors, lenses, microscopes, barometers, or hygrometers. Tools from previous grades that are not appropriate to the content of this grade level are not essential; however, these terms may be used as distracters (incorrect answer options) for assessment, for example, eyedroppers, pan balances, graduated syringes, or tuning forks. Students do not need to convert measurements from English to metric or metric to English.

Assessment Guidelines:
The objective of this indicator is to *use* tools safely, accurately, and appropriately when gathering data; therefore, the primary focus of assessment should be to apply correct procedures to the use of a compass, an anemometer, mirrors, and a prism and other tools essential to the grade level that would be needed to conduct a science investigation. However, appropriate assessments should also require students to *identify* appropriate uses for a compass, an anemometer, mirrors, and a prism; *illustrate* the appropriate tool for an investigation using pictures, diagrams, or words; *exemplify* the correct tool for a specific task (add to all grade levels); *recall* how to accurately determine the measurement from the tool; or *recognize* ways to use science tools safely, accurately, and appropriately.

Scientific Inquiry

4-1 The student will demonstrate an understanding of scientific inquiry, including the processes, skills, and mathematical thinking necessary to conduct a simple scientific investigation.

4-1.3 Summarize the characteristics of a simple scientific investigation that represent a fair test (including a question that identifies the problem, a prediction that indicates a possible outcome, a process that tests one manipulated variable at a time, and results that are communicated and explained).
Taxonomy Level: 2.4-B Understand Conceptual Knowledge

Previous/Future knowledge: In 1st grade (1-1.3), students carried out simple scientific investigations when given clear directions. In 2nd grade (2-1.1), students carried out simple scientific investigations to answer questions about familiar objects and events. In 3rd grade, students explained why similar investigations might produce different results (3-1.7) and generated questions such as "what if?" or "how?" about objects, organisms, and events in the environment and use those questions to conduct a simple scientific investigation (3-1.3). In 5th grade, students will identify independent (manipulated), dependent (responding), and controlled variables in an experiment (5-1.2) and will plan and conduct controlled scientific investigations, manipulating one variable at a time (5-1.3). In 7th grade (7-1.3), students will explain the reasons for testing one independent variable at a time in a controlled scientific investigation.

It is essential for students to know the characteristics of a simple scientific investigation that represent a fair test.

- A *fair test* is one in which only one factor is changed or tested in the experiment so that it can be determined whether or not that factor affected the results.
- *Variables* are factors that can affect the results of an experiment. Before an investigation begins, the variables that could affect the results must be identified. Then it should be determined which one variable to change or test and which conditions should be kept the same in the experiment.
  - A *manipulated variable* is the one factor that is changed or tested by the person doing the investigation.
  - A *responding variable* is the result of, or response to, the changing of the manipulated variable.

In a *simple scientific investigation* the following steps should be included:

- Identify a testable question (tests one variable) that can be investigated
- Do some simple research about the topic
- State a prediction that answers the question based on your research
- Design an experiment to test the prediction
  - List the materials needed to conduct the experiment
  - List the steps to be followed to set up a fair test
- Record and organize data (observations) in tables, graphs, or charts
- Study the data in the tables, graphs, or charts to figure out what the data means
- Explain the results (response to the manipulated variable)
- Compare the results to your prediction

It is not essential for students to identify a manipulated variable as the independent variable or recognize the responding variable as the dependent variable in an investigation.

Scientific Inquiry

4-1 The student will demonstrate an understanding of scientific inquiry, including the processes, skills, and mathematical thinking necessary to conduct a simple scientific investigation.

Assessment Guidelines:

The objective of this indicator is to *summarize* the characteristics of a simple scientific investigation that represent a fair test; therefore, the primary focus of assessment should be to give major points about the steps of a scientific investigation as listed in the indicator. However, appropriate assessments should also require students to *identify* individual parts of an investigation that make a fair test; *recognize* parts of a simple scientific investigation; *explain* why only one variable is manipulated in a fair test; *exemplify* investigations that represent a fair test; or *classify* or *identify* a variable as manipulated or controlled.

Scientific Inquiry

4-1 The student will demonstrate an understanding of scientific inquiry, including the processes, skills, and mathematical thinking necessary to conduct a simple scientific investigation.

4-1.4 Distinguish among observations, predictions, and inferences.
Taxonomy Level: 4.1-B Analyze Conceptual Knowledge

Previous/Future knowledge: In kindergarten, students identified observed objects or events by using the senses (K-1.1) and predicted and explained information or events based on observation or previous experience (K-1.3). In 2nd (2-1.4), students inferred explanations regarding scientific observations and experiences. In 3rd grade, students predict outcomes of simple investigations (3-1.4) and inferred meaning from data communicated in graphs, tables, and diagrams (3-1.6).

It is essential for students to know how to distinguish among observations, predictions, and inferences. Observing, predicting, and inferring are interrelated skills.

- *Observation*— qualitative and quantitative information gained by carefully identifying and describing properties using the five senses or scientific tools.
- *Prediction*— an inference made about what will happen in the future; it is based on observations, available data, and prior knowledge. A prediction is not a guess.
- *Inference*—an explanation or interpretation of an observation based on prior experiences or facts. They are not final explanations of the observation. There may be several logical inferences for a given observation. There is no way to be sure which inference best explains the observation without further investigation.

For example, the following observation, prediction and inference were made about this picture.

- Observation: The elephants are facing each other.
- Prediction: The elephants are going to fight.
- Inference: The elephants are mad at each other.

Scientists use these skills to make sense of the world. As new observations are made, inferences are proposed to explain what has been observed and what has not yet been observed. Inferences that state what has not yet been observed are called predictions.

It is not essential for students to formulate a hypothesis as a prediction.

Assessment Guidelines:
The objective of this indicator is to *distinguish* among observations, predictions, and inferences; therefore, the primary focus of assessment should be to determine how observations, predictions, and inferences relate to one another. However, appropriate assessments should also require students to *identify* or *classify* a statement as an observation, prediction, or inference; or *exemplify* an observation, prediction, or inference.

Scientific Inquiry

4-1 The student will demonstrate an understanding of scientific inquiry, including the processes, skills, and mathematical thinking necessary to conduct a simple scientific investigation.

4-1.5 Recognize the correct placement of variables on a line graph.
Taxonomy Level: 1.1-A Remember Factual Knowledge

Previous/Future knowledge: In 2nd grade (2-1.3), students represented and communicated simple data and explanations through drawings, tables, pictographs, and bar graphs. This is the first time that students have been introduced to variables in relation to graphs. In 5th grade, students will identify independent (manipulated), dependent (responding), and controlled variables in an experiment (5-1.2) and will construct a line graph from recorded data with correct placement of independent (manipulated) and dependent (responding) variables (5-1.5). In 7th grade (7-1.5), students will explain the relationship between independent and dependent variables in controlled a scientific investigation through the use of appropriate graphs, tables, and charts.

It is essential for students to know that line graphs show the relationship between variables in an investigation.

- A *manipulated variable* is the factor that is changed in an investigation.
  - The manipulated variable is always located on the x-axis.
- A *responding variable* is the result or response to the manipulated variable.
  - The responding variable is always located on the y-axis.

NOTE TO TEACHER: Students will construct line graphs in 4-1.6.

It is not essential for students to identify variables as independent or dependent.

Assessment Guidelines:
The objective of this indicator is to *recognize* the correct placement of variables on a line graph; therefore, the primary focus of assessment should be to identify the location of the manipulated and the responding variables on the axes of a line graph.

Scientific Inquiry

4-1 The student will demonstrate an understanding of scientific inquiry, including the processes, skills, and mathematical thinking necessary to conduct a simple scientific investigation.

4-1.6 Construct and interpret diagrams, tables, and graphs made from recorded measurements and observations.
Taxonomy Level: 2.7 and 2.1 Understand Conceptual Knowledge

Previous/Future knowledge: In previous grades, students have used tools (specific to each grade) to accurately gather data appropriate data. In 2nd grade (2-1.3), students represented and communicated simple data and explanations through drawings, tables, pictographs, bar graphs, and oral and written language. In 5th grade (5-1.5), students will construct a line graph from recorded data with correct placement of independent (manipulated) and dependent (responding) variables. This is the first time that students have constructed their own diagrams, tables, and graphs.

It is essential for students to construct simple diagrams, tables and graphs (such as pictographs, bar, or line) from recorded measurements and observations.

A *diagram* is a drawing or illustration that communicates information visually. Diagrams should contain the following:
- A title or description of the object or item modeled by the diagram telling what the drawing or illustration is about
- Labels of the main points of information that help identify what is in the drawing or illustration
- A caption that explains the drawing or illustration.

A *data table* is used to organize data collected in an experiment so that it can be read easily.
- A data table should be planned before the investigation starts.
- Consider the purpose of the table, the kind and number of items to be included in the table, the number of times a measurement will be made, and the units to be used.
- Data tables are often organized in columns and rows. The columns should have headings that show the quantity and unit of the data in that column.
- The manipulated variable is listed in the column on the left side. The responding variable is listed in the column(s) on the right side.
- If qualitative data is to be gathered, include enough space to write the observations.

Graphs are visuals used to compare data. Graphs show not only information but also relationships between the data. Graphs should include:
- a labeled x-axis (with a manipulated variable) and y-axis (with a responding variable) with appropriate units
- a scale on each axis that is appropriate for the data being graphed
- a title related to the data being graphed

Different types of graphs show different types of information.
- Pictographs use pictures of objects to show quantities.
- Bar graphs are often used to compare the quantities of different qualitative factors.
- Line graphs are often used when quantitative data collected over time.
- Line graphs show how quantitative data changes over time or relationships between manipulated (changing) variable and responding (resulting) variable.

Scientific Inquiry

4-1 The student will demonstrate an understanding of scientific inquiry, including the processes, skills, and mathematical thinking necessary to conduct a simple scientific investigation.

NOTE TO TEACHER: Students should be plotting data on graphs that already contain the increments for the given data sets. Constructing graphs in 4th grade should be limited to labeling the variables on the x-axis and y-axis and plotting data. Graphs should include increments and titles.

It is also essential for students to interpret data displayed in diagrams, tables, and graphs (pictographs, bar, line, or circle).

- Diagrams can be used to identify specific parts or how they work, sequence of events, how things are alike and different, or the relationship among objects or events.
- The lines on a line graph show the pattern of changes at a glance.
- The length of the bars on a bar graph shows the quantity or amount of the qualitative factors.
- Circle graphs show parts of a whole. They make it easy to tell which is the biggest, which is the next biggest, and so on.

It is not essential for students to construct circle graphs. Students do not need to determine the increments for nor provide a title for a graph.

Assessment Guidelines:
One objective of this indicator is to *construct* diagrams, tables, and graphs made from recorded measurements and observations; therefore, the primary focus of assessment should be to arrange information recorded from measurements and observations correctly onto the appropriate display as listed in the indicator. However, appropriate assessments should also require students to *identify* the correct placement of variables on graphs and data tables; *identify* the parts of diagrams; *compare* data tables with appropriate graphs or diagrams; or *exemplify* types of graphs.

Another objective of this indicator is to *interpret* diagrams, tables, and graphs made from recorded measurements and observations; therefore, the primary focus of assessment should be to translate the data represented on diagrams, tables, and graphs. However, appropriate assessments should also require students to *summarize* diagrams, tables, and graphs made from recorded data; or *explain* information in diagrams, tables, and graphs.

Scientific Inquiry

4-1 The student will demonstrate an understanding of scientific inquiry, including the processes, skills, and mathematical thinking necessary to conduct a simple scientific investigation.

4-1.7 Use appropriate safety procedures when conducting investigations.
Taxonomy Level: 3.2-C Apply Procedural Knowledge

Previous/Future knowledge: In all grades students use appropriate safety procedures when conducting investigations that are appropriate to their grade, tools, and types of investigations.

It is essential for students to know that care should be taken when conducting a science investigation to make sure that everyone stays safe.

Safety procedures to use when conducting simple science investigations may be

- Always wear appropriate safety equipment such as goggles or an apron when conducting an investigation.
- Be careful with sharp objects and glass. Only the teacher should clean up broken glass.
- Do not put anything in the mouth unless instructed by the teacher.
- Follow all directions for completing the science investigation.
- Follow proper handling of animals in the classroom.
- Keep hands away from eyes when using iron filings.
- Keep the workplace neat. Clean up when the investigation is completed.
- Practice all of the safety procedures associated with the activities or investigations conducted.
- Tell the teacher about accidents or spills right away.
- Wash hands after each activity.

It is essential for students to use tools safely and accurately, including a compass, an anemometer, mirrors, and a prism when conducting investigations.

NOTE TO TEACHER (safety while working with students):

- Teacher materials have lists of "Safety Procedures" appropriate for the suggested activities. Students should be able to describe and practice all of the safety procedures associated with the activities they conduct.
- Most simple investigations will not have any risks, as long as proper safety procedures are followed. Proper planning will help identify any potential risks and therefore eliminate any chance for student injury or harm.
- Teachers should review with students the safety procedures before doing an activity.
- Lab safety rules may be posted in the classroom and/or laboratory where students can view them. Students should be expected to follow these rules.
- A lab safety contract is recommended to notify parents/guardians that classroom science investigations will be hands-on and proper safety procedures will be expected. These contracts should be signed by the student and the parents or guardians and kept on file to protect the student, teacher, school, and school district.
- In the event of a laboratory safety violation or accident, documentation in the form of a written report should be generated. The report should be dated, kept on file, include a signed witness statement (if possible) and be submitted to an administrator.
- Materials Safety Data Sheets (MSDS) must be on file for hazardous chemicals.
- For further training in safety guidelines, you can obtain the SC Lab Safety CD or see the Lab Safety flip-chart (CD with training or flip-chart available from the SC Department of Education).

Scientific Inquiry

4-1 The student will demonstrate an understanding of scientific inquiry, including the processes, skills, and mathematical thinking necessary to conduct a simple scientific investigation.

It is not essential for students to go beyond safety procedures appropriate to the kinds of investigations that are conducted in a fourth grade classroom.

Assessment Guidelines:
The objective of this indicator is to *use* appropriate safety procedures when conducting investigations; therefore, the primary focus of assessment should be to apply correct procedures that would be needed to conduct a science investigation. However, appropriate assessments should also require students to *identify* safety procedures that are needed while conducting an investigation; or *recognize* when safety procedures are being used.