Scientific Inquiry

7-1 The student will demonstrate an understanding of technological design and scientific inquiry, including the process skills, mathematical thinking, controlled investigative design and analysis, and problem solving.

7-1.1 Use appropriate tools and instruments (including a microscope) safely and accurately when conducting a controlled scientific investigation.
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), beakers, meter tapes and sticks, forceps/tweezers, tuning forks, graduated cylinders, and graduated syringes (3-1.5), a compass, an anemometer, mirrors, and a prism (4-1.2), a timing device and a 10x magnifier (5-1.4), and a spring scale, beam balance, barometer, and sling psychrometer (6-1.1) safely, accurately, and appropriately. In future grades, students will use these tools when appropriate as well as learn new tools to use 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 different instruments or tools are needed to collect different kinds of data. A *microscope* is a tool that is used to magnify the features of an object. A *compound microscope* has two or more lenses. Other parts of a compound microscope are:
- *Eyepiece*—contains the 10X magnifying lens
- *Coarse adjustment knob/focus*—focuses the image under low power
- *Fine adjustment knob/focus*—focuses the image under high power
- *Objective lenses*—two or three separate lenses that contain varying powers of magnifying lenses
- *Stage and stage clips*—supports and hold the microscope slide in place while viewing
- *Diaphragm*—controls the amount of light available
- *Light source*—a mirror, external or internal light source that shines light through the object being viewed
- *Arm*—supports the body tube which connects the eyepiece to the set of objective lenses
- *Base*—supports the microscope

It is essential for students to use the microscope safely and accurately.
- When looking through a microscope, the lighted area is the *field of view*.
- Adjust the diaphragm until an adequate amount of light is available.
  - To make the field of view brighter, open the diaphragm.
  - To make the field of view darker, close the diaphragm.
- To view an object under the microscope, first focus on the lowest power objective lens. Then change to the highest power objective lens if necessary.
- When focusing the image under low power objective, use the coarse adjustment knob.
- Use only the fine adjustment knob to sharpen the focus when using the high power objective.
- To calculate the magnification of objects seen through a microscope, multiply the magnification of the eyepiece times the magnification of the objective lens being used.
- Objects on the slide move in the opposite direction when being viewed through the eyepiece (for example, if the slide is moved to the left, the object being viewed appears to move to the right).

It is essential for students to use care when handling the microscope.
- A microscope should be held and carried with one hand under the base and one hand on the arm.
- Some microscopes may have a mirror as the light source. Care should be taken not to aim the mirror directly at the Sun.

Scientific Inquiry

7-1 The student will demonstrate an understanding of technological design and scientific inquiry, including the process skills, mathematical thinking, controlled investigative design and analysis, and problem solving.

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 eyedroppers, magnifiers (hand lenses), rulers (measuring to millimeters), thermometers (measuring in ^{o}F and ^{o}C), beakers (measuring to milliliters), forceps/tweezers, graduated cylinders (measuring to milliliters), meter sticks and meter tapes (measuring in meters, centimeters, or millimeters), compasses, timing devices (measuring in minutes and seconds), 10X magnifiers, or beam balances (measuring to centigrams) to gather data.

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.

It is not essential for students to use other types of microscopes or know how to prepare a wet mount slide. 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 rain gauge, measuring cups, graduated syringes, tuning forks, anemometers, plane mirrors, prisms, barometers, sling psychrometers, and spring scales. 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 microscope 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 microscope; *illustrate* the appropriate tool for an investigation using pictures, diagrams, or words; *recall* how to accurately determine the measurement from the tool; or *recognize* ways to use science tools safely, accurately, and appropriately.

Scientific Inquiry

7-1 The student will demonstrate an understanding of technological design and scientific inquiry, including the process skills, mathematical thinking, controlled investigative design and analysis, and problem solving.

7-1.2 Generate questions that can be answered through scientific investigation.
Taxonomy Level: 6.1-B Create Conceptual Knowledge

Previous/Future knowledge: In 3rd grade (3-1.3), students 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. In 5th grade (5-1.1), students identified questions suitable for generating a hypothesis. In 8th grade (8-1.4), students will generate questions for further study on the basis of prior investigations.

It is essential for students to know that only testable questions (which are used to test one independent (manipulated) variable) can be answered through a scientific investigation and data collection. The question should include the relationship between the independent (manipulated) and dependent (responding) variable. For example, the following are examples of testable questions:

- How does the amount of exercise affect heart rate and breathing rate?
  - The independent (manipulated) variable is the amount of exercise (number of repetitions, amount of weights, duration of exercise).
  - The dependent (responding) variable, involving two body systems interacting, are heart rate and breathing rate.
- How does the amount of clay in soil affect permeability of water?
  - The independent (manipulated) variable is amount of clay in the soil.
  - The dependent (responding) variable is the rate of permeability of water.
- Does the amount of baking soda added to vinegar affect the amount of gas produced?
  - The independent (manipulated) variable is amount of baking soda.
  - The dependent (responding) variable is amount of gas produced.

It is also essential for students to know that a prediction about the relationship between variables is formed from the testable question. This prediction is called a *hypothesis*.

- All controlled investigations should have a hypothesis.
- A hypothesis can be stated positively or negatively. For example,
  - The longer the duration of exercise, the faster the heart and breathing rate. (positive statement)
  - The more clay in the soil, the lower the rate of permeability of water. (negative statement)
  - The more baking soda added to the vinegar, the greater the amount of gas produced in the reaction. (positive statement)
- A hypothesis can also be stated as a cause-and-effect ("If…then,…") statement. For example, "If there is more clay in the soil, then the rate of permeability will increase."
- The experiment is conducted to support or not support a hypothesis. If the hypothesis is not supported in the experiment, it can still be used to help rule out some other ideas.

It is not essential for students to generate questions based on prior investigations, develop a problem statement instead of a question for an investigation, or understand a null hypothesis.

Scientific Inquiry

7-1 The student will demonstrate an understanding of technological design and scientific inquiry, including the process skills, mathematical thinking, controlled investigative design and analysis, and problem solving.

Assessment Guidelines:

The objective of this indicator is to *generate* questions that can be answered through scientific investigations; therefore, the primary focus of assessment should be to construct questions that can be tested and answered by conducting scientific investigations. However, appropriate assessments should also require students to *identify* the experimental variables in the question; *exemplify* questions that can be tested through scientific investigations; *exemplify* hypotheses appropriate to a given question; or *compare* the hypothesis to the question in an investigation.

Scientific Inquiry

7-1 The student will demonstrate an understanding of technological design and scientific inquiry, including the process skills, mathematical thinking, controlled investigative design and analysis, and problem solving.

7-1.3 Explain the reasons for testing one independent variable at a time in a controlled scientific investigation.
Taxonomy Level: 2.7-C Understand Procedural Knowledge

Previous/Future knowledge: In 3rd grade (3-1.7), students explained why similar investigations might produce different results. In 4th grade (4-1.3), students summarized 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). In 5th grade, students identified independent (manipulated), dependent (responding), and controlled variables in an experiment (5-1.2) and planned and conducted controlled scientific investigations, manipulating one variable at a time (5-1.3). In 8th grade, students will recognize the importance of a systematic process for safely and accurately conducting investigations (8-1.2) and will explain the importance of and requirements for replication of scientific investigations (8-1.5).

It is essential for students to know that a *controlled scientific investigation* determines the effect of an independent variable in an experiment, when all other variables are controlled. Every controlled scientific investigation provides information. This information is called *data*. Data includes both scientific observations and inferences.

- A *scientific observation* is gained by carefully identifying and describing properties using the five senses or scientific tools and can be classified as *quantitative* or *qualitative*.
    - Quantitative observations are observations that use numbers (amounts) or measurements (including the unit label) or observations that make relative comparisons, such as more than, all, less than, few, or none.
    - Qualitative observations are observations that are made using only the senses and refer to specific properties.
- An *inference* is an explanation or interpretation of an observation based on prior experiences or supported by observations made in the investigation. 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.

In order to design a *controlled scientific investigation* some or all of the following steps should be included:

- Identify a testable question (tests one variable) that can be investigated
- Research information about the topic
- State the hypothesis as a predicted answer to the question, what may be the possible outcome of the investigation
- Design an experiment to test the hypothesis, controlling all variables except the independent (manipulated) variable
    - Plan for independent (manipulated) and dependent (responding) variables with repeated trials
    - Plan for factors that should be held constant (controlled variables) and/or plan for a control set-up
    - List the materials needed to conduct the experiment
    - List the procedures to be followed
    - Plan for recording, organizing and analyzing data

Scientific Inquiry

7-1 The student will demonstrate an understanding of technological design and scientific inquiry, including the process skills, mathematical thinking, controlled investigative design and analysis, and problem solving.

- Conduct the experiment and record data (observations) in tables, graphs, or charts
- Analyze the data in the tables, graphs, or charts to figure out what the data means (describe the relationship between the variables)
- Compare the results to the hypothesis and write a conclusion statement that will support or not support the hypothesis based on the recorded data
- Communicate the results to others

It is also essential for students to know that if there is only one independent (manipulated) variable, then there is only one factor that can affect the results of an experiment.
- Before beginning an investigation, all potential factors that could affect the results should be listed. From this list, the independent (manipulated) variable should be determined while planning to control all other variables.
- Once the independent (manipulated) variable is identified, then all other factors that may influence the experiment need to be controlled.
- When more than one variable is allowed to affect the dependent (responding) variables or the outcome of the investigation, then a fair test is not conducted.
- When more than one factor at a time is changed, reasonable conclusions cannot be made.
- A controlled variable is kept constant so that it does not affect the outcome of the experiment.
- Some experiments may have a control set-up (or group) so that the experimental results can be compared to the control results.
  - The control set-up (or group) is treated like the experimental group except the independent (manipulated) variable is not applied.

It is not essential for students to evaluate an investigation as to how it was planned and conducted.

It is also essential for students to know that science is the process of learning about the natural world by asking questions and trying to find the answers to those questions. Technology applies scientific knowledge in order to develop a solution to a problem or create a product to help meet human needs. Technology is usually developed because there is a need or a problem that needs to be solved. Steps in the technological design process include:
- *Identifying a problem or need*
  - Research and gather information on what is already known about the problem or need
- *Designing a solution or a product*
  - Generate ideas on possible solutions or products
  - Evaluate the factors that will limit or restrict the solution or product design
  - Determine the trade-offs of the solutions or products (what must be given up in order to create the solution or product)
- *Implementing the design*
  - Build and test the solution or product
  - Identify any problems with the solution or product
  - If necessary, redesign the solution or product to eliminate any problems in the design
- *Evaluating the solution or the product*
  - Determine if the solution or product solved the problem
  - Identify the pros and cons of the solution or product

Scientific Inquiry

7-1 The student will demonstrate an understanding of technological design and scientific inquiry, including the process skills, mathematical thinking, controlled investigative design and analysis, and problem solving.

The steps of the design can be communicated using descriptions, models, and drawings.

- A *scientific model* is an idea that allows us to create explanations of how the something may work. Models can be physical or mental.

It is not essential for students to compare the processes of a controlled scientific investigation and the technological design process or evaluate a technological design or product on the basis of designated criteria (including cost, time, and materials).

Assessment Guidelines:

The objective of this indicator is to *explain* the reasons for testing one independent variable at a time in a controlled scientific investigation; therefore, the primary focus of assessment should be to construct a cause-and-effect model of why only one independent variable should be tested. However, appropriate assessments should also require students to *identify* reasons for controlling variables in an investigation; *identify* the variables in an investigation; *recognize* an investigation that tests only one independent variable; *compare* the control set-up to the experimental design; *summarize* the steps of a controlled scientific investigation; *exemplify* technology; *match* a specific solution or product to a specific need or problem; or *summarize* the steps in the technological design process.

Scientific Inquiry

7-1 The student will demonstrate an understanding of technological design and scientific inquiry, including the process skills, mathematical thinking, controlled investigative design and analysis, and problem solving.

7-1.4 Explain the importance that repeated trials and a well-chosen sample size have with regard to the validity of a controlled scientific investigation.
Taxonomy Level: 2.7-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 (3-1.7), students explained why similar investigations might produce different results. In 4th grade (4-1.3), students summarized 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). In 8th grade, students will recognize the importance of a systematic process for safely and accurately conducting investigations (8-1.2) and will explain the importance of and requirements for replication of scientific investigations (8-1.5).

It is essential for students to know that for an investigation to be scientifically valid, replication within the procedures is important to verify the results and produce valid conclusions. Scientists want to report true results; therefore, they conduct repeated trials so that patterns or trends in the data can be determined. The more data that is collected through replication, the more reliable the results. Without replication, errors in procedures or data collection may not be detected.

While gathering data during an experiment:

- Data needs to be gathered more than one time under the same conditions and with the same measurement tools.
- Repetition ensures that the experiment is *valid* and that the data is reliable.
    - Validity indicates how close the investigation is to being accurate and dependable.
    - As a result of validity, other investigations repeated the same way should produce similar results.
- When possible, measurements should be taken several times, and then the results averaged.
- Each set of repeated data is called a *trial*.

An investigation may involve a *sample*, or a portion of the total number, as a type of estimation.

- The sample is used to take a representative portion of the objects or population for research.
- A poorly chosen sample size can be unrepresentative of the whole.
- Careful observations made from a proper sample size or manipulating variables within that sample size result in information and conclusions that might apply to the whole population.

If an investigation is designed with too few trials or with an improper (too small) sample size, experimental data and the results will have invalid foundations. Reasons why a repeated investigation could produce different results may be:

- The setup of the materials was not followed properly.
- Similar procedures were not followed in the exact same way.
- Appropriate tools were not chosen to complete the investigation.
- Tools were not used properly.
- Measurements were not taken accurately.
- Different observations were collected.
- Mistakes were made when recording data such as numbers written incorrectly.

Scientific Inquiry

7-1 The student will demonstrate an understanding of technological design and scientific inquiry, including the process skills, mathematical thinking, controlled investigative design and analysis, and problem solving.

Assessment Guidelines:

The objective of this indicator is to *explain* the importance that repeated trials and well-chosen sample sizes have with regard to the validity of a controlled scientific investigation; therefore, the primary focus of assessment should be to construct a cause-and-effect model showing the importance of repeated trials and well-chosen sample sizes to ensure validity. However, appropriate assessments should also require students to *summarize* reasons why the results of an investigation may produce different results; *recall* the importance of a well-chosen sample size; *identify* conditions necessary to collect valid data; or *exemplify* valid investigations.

Scientific Inquiry

7-1 The student will demonstrate an understanding of technological design and scientific inquiry, including the process skills, mathematical thinking, controlled investigative design and analysis, and problem solving.

7-1.5 Explain the relationships between independent and dependent variables in a controlled scientific investigation through the use of appropriate graphs, tables, and charts.
Taxonomy Level: 2.7-B Understand Conceptual Knowledge

Previous/Future knowledge: In 4th grade, students recognized the correct placement of variables on a line graph (4-1.5) and constructed and interpreted diagrams, tables, and graphs made from recorded measurements and observations (4-1.6). In 5th grade (5-1.5), students constructed a line graph from recorded data with correct placement of independent (manipulated) and dependent (responding) variables. In 8th grade (8-1.3), students will construct explanations and conclusions from interpretations of data obtained during a controlled scientific investigation.

It is essential for students to know that the relationship between the independent (manipulated) variable and the dependent (responding) variables can be interpreted through the use of appropriate graphs, tables, and charts.

- Graphs convert data sets into an organization form that is often better understood than written narratives or columns of numbers.
  - Graphs contain a title, increments, and labeled axes.
  - The horizontal and vertical axes of the graphs identify the variables.
    - The horizontal axis identifies the independent (manipulated) variable.
    - The vertical axis identifies the dependent (responding) variable.
    - For each independent (manipulated) variable number there is a corresponding dependent (responding) variable number.
- Different graphs are used to represent different types of data.
  - Bar graphs organize descriptive data that comes from research questions asking about variables that will be counted and are often used to compare the quantities of different qualitative factors.
  - Line graphs display continuous data that comes from questions that ask about variables that investigated over time.
  - Line graphs show how quantitative data changes over time or relationships between manipulated (changing) variable and responding (resulting) variable.
- Data tables and charts allow data that include numbers and measurements to be displayed in an organized fashion.
  - A data table should be planned before the investigation starts.
  - The independent (manipulated) variable is listed in the column on the left side.
  - The dependent (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.
- The relationship between the independent (manipulated) and dependent (responding) variable can be interpreted using the presented graph, table, or chart. For example,
  - On a line graph, if the slope of the line is positive, then the relationship between the variables is also positive.
  - On a bar graph, if the height of the bar is lower than the others, the quantity is less.

NOTE TO TEACHER: A mnemonic device that can be used to teach the appropriate locations of the variables on a graph is DRY MIX.

- DRY represents Dependent-Responding-Y-axis.
- MIX represents Manipulated-Independent-X-axis.

Scientific Inquiry

7-1 The student will demonstrate an understanding of technological design and scientific inquiry, including the process skills, mathematical thinking, controlled investigative design and analysis, and problem solving.

It is not essential for students to use statistical analysis to explain the results of an investigation or the relationship between variables.

Assessment Guidelines:

The objective of this indicator is to *explain* the relationship between independent and dependent variables in a controlled scientific investigation through the use of appropriate graphs, tables, and charts; therefore, the primary focus of assessment should be to construct a cause-and-effect model of the relationship between variables. However, appropriate assessments should also require students to *identify* the correct placement of variables on graphs; *recognize* appropriate increments for a graph of recorded data; *compare* data to an appropriate graph; *exemplify* appropriate graphs from recorded data; *compare* graphs, tables, or charts with recorded data; or *interpret* the relationship between the variables as presented on a graph, table, or chart.

Scientific Inquiry

7-1 The student will demonstrate an understanding of technological design and scientific inquiry, including the process skills, mathematical thinking, controlled investigative design and analysis, and problem solving.

7-1.6 Critique a conclusion drawn from a scientific investigation.
Taxonomy Level: 5.2-B Evaluate Procedural Knowledge

Previous/Future knowledge: In 2nd grade (2-1.4), students inferred explanations regarding scientific observations and experiences. In 3rd grade (3-1.6), students inferred meaning from data communicated in graphs, tables, and diagrams. In 5th grade, students evaluated results of an investigation to formulate a valid conclusion based on evidence and communicated the findings of the evaluation in oral or written form (5-1.6) and also planned and conducted controlled scientific investigations, manipulating one variable at a time (5-1.3). In 6th grade (6-1.4), students used a technological design process to plan and produce a solution to a problem or a product (including identifying a problem, designing a solution or a product, implementing the design, and evaluating the solution or the product). In 8th grade (8-1.3), students will construct explanations and conclusions from interpretations of data obtained during a controlled scientific investigation.

It is essential for students to know that once the results of an investigation are collected and recorded in appropriate graphs, tables or charts, the data should be analyzed to figure out what the data means. The results of the investigation are then compared to the hypothesis. A *valid conclusion* can then be written and should include:
- The relationship between the independent (manipulated) variable and dependent (responding) variables based on the recorded data, and
- Whether the hypothesis was supported or not supported.

Inferences are sometimes needed to help form a valid conclusion.
- An *inference* is an explanation of the data that is based on facts, but not necessarily direct observation.

The conclusion is then communicated to allow others to evaluate and understand the investigation.

Assessment Guidelines:
The objective of this indicator is to *critique* a conclusion drawn from a scientific investigation; therefore, the primary focus of assessment should be to determine whether a conclusion is appropriate for a given scientific investigation. However, appropriate assessments should also require students to *summarize* the steps in a controlled scientific investigation; *compare* a conclusion to the appropriate investigation; *compare* a conclusion to a given hypothesis; or *select* an appropriate conclusion for a given investigation.

Scientific Inquiry

7-1 The student will demonstrate an understanding of technological design and scientific inquiry, including the process skills, mathematical thinking, controlled investigative design and analysis, and problem solving.

7-1.7 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 type 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 must 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 live or preserved organisms in the classroom.
- 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.
- Use caution when working with chemicals.
- Use caution when working with heat sources and heated objects.
- Wash hands after each activity.

It is essential for students to use tools safely and accurately, including a microscope, 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 conducted.
- 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

7-1 The student will demonstrate an understanding of technological design and scientific inquiry, including the process skills, mathematical thinking, controlled investigative design and analysis, and problem solving.

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