Introduction to the performance standards for Science

There are two widely used and respected national documents in science which we have taken into account: the National Research Council (NRC) National Science Education Standards (1996) and the American Association for the Advancement of Science (AAAS) Project 2061 Benchmarks for Science Literacy (1993). We found the AAAS analysis of the Benchmarks and the NRC Draft to be helpful in seeing the substantial degree of agreement between the two documents. We also consulted New Standards partner statements about standards and international documents, including the work of the Third International Mathematics and Science Study and the Organisation for Economic Co-operation and Development. Many of these sources, like the Benchmarks, give greater emphasis to technology and the applications of science than does the NRC.

The framework for the Science performance standards reflects New Standards partner representatives’ distillation of these several sources of guidance:

S1 Physical Sciences Concepts;
S2 Life Sciences Concepts;
S3 Earth and Space Sciences Concepts;
S4 Scientific Connections and Applications;
S5 Scientific Thinking;
S6 Scientific Tools and Technologies;
S7 Scientific Communication;
S8 Scientific Investigation.

As the amount of scientific knowledge explodes, the need for students to have deep understanding of fundamental concepts and ideas upon which to build increases; as technology makes information readily available, the need to memorize vocabulary and formulas decreases. There is general agreement among the science education community, in principle, that studying fewer things more deeply is the direction we would like to go. The choices about what to leave out and what to keep are hotly debated. There are 855 benchmarks and the content standards section of the NRC standards runs nearly 200 pages, so there are still choices to be made in crafting a reasonable set of performance standards.

When the goal is deep understanding, it is necessary to revisit concepts over time. Students show progressively deeper understanding as they use the concept in a range of familiar situations to explain observations and make predictions, then in unfamiliar situations; as they represent the concept in multiple ways (through words, diagrams, graphs, or charts), and explain the concept to another person. The conceptual understanding standards make explicit that students should be able to demonstrate understanding of a scientific concept “by using a concept accurately to explain observations and make predictions and by representing the concept in multiple ways (through words, diagrams, graphs, or charts, as appropriate).” Both aspects of understanding—explaining and representing—are required to meet these standards.

For most people and most concepts, there is a progression from phenomenological to empirical to theoretical, or from a qualitative to a quantitative understanding. We have chosen one important concept, density, to illustrate the progression. To do this, we use “Flinkers” at the elementary school level (see Volume 1, page 136), “Discovering Density” at the middle school level (see Volume 2, page 101), and “The Density of Sand” at the high school level (see page 86). The expectation for any particular concept at any particular level can only be described with a satisfactory degree of precision and accuracy in the degree of detail adopted by AAAS and NRC; we strongly urge users of these performance standards to consult either or both of those documents for guidance on other concepts.

Complementing the conceptual understanding standards, S5 – S8 focus on areas of the science curriculum that need particular attention and a new or renewed emphasis:

S5 Scientific Thinking;
S6 Scientific Tools and Technologies;
S7 Scientific Communication;
S8 Scientific Investigation.

Establishing separate standards for these areas is a mechanism for highlighting the importance of these areas, but does not imply that they are independent of conceptual understanding. The NRC standards, by declaring that inquiry is not only a teaching method but also an object of study, should put the time-worn “content versus process” debate to rest, and focus effort on combining traditionally defined content with process. As the work samples that follow illustrate, good work usually provides evidence of both.
Resources

Reviewers of drafts of these performance standards have pointed out that our expectations are more demanding, both in terms of student time and access to resources, than they consider reasonable for all students. We acknowledge the distance between our goals and the status quo, and the fact that there is a tremendous disparity in opportunities between the most and least advantaged students. We think that there are at least two strategies that must be pursued to achieve our goals—making better use of existing, out-of-school resources and making explicit the connection between particular resources and particular standards.

Best practice in science has always included extensive inquiry and investigation, but it is frequently given less emphasis in the face of competing demands for student time and teacher resources. An elementary teacher faced with the unfamiliar territory of project work in science or a secondary teacher faced with the prospect of guiding 180 projects and investigations can legitimately throw up his or her hands and cry, “Help!” Youth and community-based organizations, such as the Boy Scouts of America, Girl Scouts of the U.S.A., and 4-H, have science education on their agenda. Thus, we have incorporated examples of projects and investigations that are done outside of school to make clear that help is available.

We acknowledge that some of the performance descriptions and examples presuppose resources that are not currently available to all students, even those who take advantage of the out-of-school opportunities available to them. Yet, New Standards partners have adopted a Social Compact, which says, in part, “Specifically, we pledge to do everything in our power to ensure all students a fair shot at reaching the new performance standards...This means that they will be taught a curriculum that will prepare them for the assessments, that their teachers will have the preparation to enable them to teach it well, and there will be an equitable distribution of the resources the students and their teachers need to succeed.”

All of the district, state, and national documents in science make explicit the need for students to have hands-on experience and to use information tools. Thus, for example, §6, Scientific Tools and Technologies, makes explicit reference to using telecommunications to acquire and share information. A recent National Center for Education Statistics survey recently reported that only 30% of schools and fewer than 9% of instructional rooms currently have access to the Internet. We know that this is an equity issue—that far more than 9% of the homes in the United States have access to the Internet and that schools must make sure that students’ access to information and ideas does not depend on what they get at home—so we have crafted performance standards that would use the Internet so that people will make sure that all students have access to it. Since the New Standards partners have made a commitment to create the learning environments where students can develop the knowledge and skills that are delineated here, we hope that making these requirements explicit will help those who allocate resources to understand the consequences of their actions in terms of student performance.
S1 Physical Sciences Concepts

The student demonstrates conceptual understanding by using a concept accurately to explain observations and make predictions and by representing the concept in multiple ways (through words, diagrams, graphs or charts, as appropriate). Both aspects of understanding—explaining and representing—are required to meet this standard.

The student produces evidence that demonstrates understanding of:

5i a Structure of atoms, such as atomic composition, nuclear forces, and radioactivity.
5i b Structure and properties of matter, such as elements and compounds; bonding and molecular interaction; and characteristics of phase changes.
5i c Chemical reactions, such as everyday examples of chemical reactions; electrons, protons, and energy transfer; and factors that affect reaction rates such as catalysts.
5i d Motions and forces, such as gravitational and electrical; net forces and magnetism.
5i e Conservation of energy and increase in disorder, such as kinetic and potential energy; energy conduction, convection, and radiation; random motion; and effects of heat and pressure.
5i f Interactions of energy and matter, such as waves, absorption and emission of light, and conductivity.

Examples of activities through which students might demonstrate conceptual understanding of physical sciences include:

Debate the relative merits of harnessing nuclear fission and fusion as energy sources. 1a, 1b, 1c, 3b
Predict the age of a hypothetical fossil based on the rate of radioactive decay of several radioactive isotopes. 1a, 2c, 3a, 3b, 3c, 3d
Research the history of the periodic table; take and defend a position on the configuration that best illustrates properties of elements. 1a, 1b, 1c, 4d
Determine the characteristics for a dinner table candle that will keep the candle burning longer. 1c, 1e
Explain why a local urban area has smog and what can be done about it. 1a, 1b, 1c, 1e, 4d
Make an informational videotape describing how an understanding of acceleration and velocity can make one a better driver. 1a, 1e, 7d
Explain how electric motors and generators illustrate the relationship between electricity and magnetism. 1c, 1d, 1e, 4a, 4b
Explain to a younger student the difference between temperature and heat. 1e, 7d
Compare the efficiency and energy consumption of several different methods of generating electricity that could be used locally. 1b, 1f, 4b, 4d
Earn the Energy Merit Badge (Boy Scouts of America) and explain how it helped you to understand the interactions of matter and energy. 1f, 4b, 4d
Trace the transformations of energy from the electric current that enters a CD player or boombox to a sound that can be heard as music. 1f, 4b

S2 Life Sciences Concepts

The student demonstrates conceptual understanding by using a concept accurately to explain observations and make predictions and by representing the concept in multiple ways (through words, diagrams, graphs or charts, as appropriate). Both aspects of understanding—explaining and representing—are required to meet this standard.

The student produces evidence that demonstrates understanding of:

5a The cell, such as cell structure and function relationships; regulation and biochemistry; and energy and photosynthesis.
5b Molecular basis of heredity, such as DNA, genes, chromosces, and mutations.
5c Biological evolution, such as speciation, biodiversity, natural selection, and biological classification.
5d Interdependence of organisms, such as conservation of matter; cooperation and competition among organisms in ecosystems; and human effects on the environment.
5e Matter, energy, and organization in living systems, such as matter and energy flow through different levels of organization; and environmental constraints.
5f Behavior of organisms, such as nervous system regulation; behavioral responses; and connections with anthropology, sociology, and psychology.

Examples of activities through which students might demonstrate conceptual understanding of life sciences include:

Create a picture book to explain how a producer converts solar energy to chemical energy through an ecosystem. 2a, 1c, 3a
Explain how cell functions are regulated to allow organisms to respond to the environment and to control and coordinate growth and differentiation. 2a, 2b, 2c, 2f, 1c
Predict how long a plant will live planted in a closed glass jar located by a window; and explain what additional information regarding the plant and the surrounding environment would be needed to improve the prediction. 2a, 1a, 3a, 3b
Create a working model to show how the instructions for specifying an organism’s characteristics are carried in DNA and its subunits. 2b, 2c, 5c
Make a videotape debating the possible explanations for the extinction of dinosaurs. 2c, 2d, 7d
Make a storyboard and give a presentation to younger students explaining the increasing prevalence of dark forms of moths 150 years ago and the more recent return to light forms. 2b, 2c, 2d, 7d, 3c
Make a humorous travel brochure describing the pathway of a carbon dioxide molecule and an oxygen molecule through the living and non-living components of the biosphere. 2c, 1b
Earn the Ecology Merit Badge (Girl Scouts of the U.S.A.) or the Environmental Science Merit Badge (Boy Scouts of America) and explain how it helped you to understand the interdependence of organisms. 2d, 2e
Trace a candy bar from the time it is purchased to the time it is completely expended. 2a
Develop a recycling outreach program as part of a community service project to illustrate the limited availability of matter and energy in the ecosystem. 2c, 2d, 1c, 4b
Conduct an investigation to determine how different kinds of plants respond to various environmental stimuli. 2f
Research the development of, and recent advances in the theory of, evolutionary psychology. 2c, 2f, 4c
Earth and Space Sciences Concepts

The student demonstrates conceptual understanding by using a concept accurately to explain observations and make predictions and by representing the concept in multiple ways (through words, diagrams, graphs, or charts, as appropriate). Both aspects of understanding—explaining and representing—are required to meet this standard.

The student produces evidence that demonstrates understanding of:

S3 a Energy in the Earth system, such as radioactive decay, gravity, the Sun’s energy, convection, and changes in global climate.
S3 b Geochemical cycles, such as conservation of matter; chemical resources and movement of matter between chemical reservoirs.
S3 c Origin and evolution of the Earth system, such as geologic time and the age of life forms; origin of life; and evolution of the Solar System.
S3 d Origin and evolution of the universe, such as the “big bang” theory; formation of stars and elements; and nuclear reactions.
S3 e Natural resource management.

Examples of activities through which students might demonstrate conceptual understanding of Earth and space sciences include:

- Make a brochure providing an orientation to the climate of the local region to a newcomer; and explain the likely weather in that context. 3a
- Explain the relationship between gravity and energy. 3a, 1d
- Analyze the risk of natural disasters in the local region and make recommendations for actions that can be taken to mitigate the damage. 3a, 3b, 4b
- Germinate seeds on a rotating platform and explain the observed growth pattern. 3a, 1d, 2e
- Conduct a study of the geology of an area near the school; and describe the likely history of the region, using observations and reference materials. 3b, 3c
- Diagram the birth, development, and death of a human; contrast with the geologic time frame of the origin and evolution of the Earth system or the universe. 3c, 3d, 2c
- Work with other students to become an “expert panel” to describe the historical events leading to the development of the “big bang” theory. 3c, 3d, 5f
- Write a research paper to explain how stars produce energy from nuclear reactions and how these processes led to the formation of other elements. 3d, 1a, 1b, 1c, 1f, 2a
- Identify a place that is subject to periodic flooding, evaluate its positive and negative effects, and study different ways of maintaining, reducing, or eliminating the likelihood of flooding. 3e

Scientific Connections and Applications

The student demonstrates conceptual understanding by using the concept to explain observations and make predictions and by representing the concept in multiple ways (through words, diagrams, graphs, or charts, as appropriate). Both aspects of understanding—explaining and representing—are required to meet this standard.

The student produces evidence that demonstrates understanding of:

S4 a Big ideas and unifying concepts, such as order and organization; models, form and function; change and constancy; and cause and effect.
S4 b The designed world, such as the reciprocal relationship between science and technology; the development of agricultural techniques; and the reasonableness of technological designs.
S4 c Health, such as nutrition and exercise; disease and epidemiology; personal and environmental safety; and resources, environmental stress, and population growth.
S4 d Impact of technology, such as constraints and trade-offs; feedback; benefits and risks; and problems and solutions.
S4 e Impact of science, such as historical and contemporary contributions; and interactions between science and society.

Examples of activities through which students might demonstrate conceptual understanding of scientific connections and applications include:

- Construct a computer-controlled robot arm that mimics the form and function of a human hand and forearm. 4a, 4b, 4c, 2a
- Work with other students to give a presentation based on scientific principles arguing for a systemic solution to an environmental problem that concerns the school or community. 4a, 4b, 4c, 4d, 1a, 2d, 2e, 4b
- Propose modifications to improve skateboards, in-line skates, bicycles, or similar objects to make them safer, faster, or less expensive. 4b, 4c, 1a, 4b
- Conduct a study of the school cafeteria including: food storage and preparation, nutrition, and student preferences; and make recommendations for improvement. 4c, 4d
- Debate the positive and negative consequences of a recently developed technological innovation. 4b, 4d, 1b, 4e
- Earn the Food, Fibers, and Farming Merit Badge (Girl Scouts of the U.S.A.) and make a poster that shows understanding of agriculture or technology. 4b, 4d, 4e

Samples of student work that illustrate standard-setting performances for these standards can be found on pages 86-105.

The examples that follow the performance descriptions for each standard are examples of the work students might do to demonstrate their achievement. The examples also indicate the nature and complexity of activities that are appropriate to expect of students at the high school level.

The cross-references that follow the examples highlight examples for which the same activity, and possibly even the same piece of work, may enable students to demonstrate their achievement in relation to more than one standard. In some cases, the cross-references highlight examples of activities through which students might demonstrate their achievement in relation to standards for more than one subject matter.
$5$ **Scientific Thinking**

The student demonstrates skill in scientific inquiry and problem solving by using thoughtful questioning and reasoning strategies, common sense and diverse conceptual understanding, and appropriate ideas and methods to investigate science; that is, the student:

- Frames questions to distinguish cause and effect; and identifies or controls variables in experimental and non-experimental research settings.
- Uses concepts from Science Standards 1 to 4 to explain a variety of observations and phenomena.
- Uses evidence from reliable sources to develop descriptions, explanations, and models; and makes appropriate adjustments and improvements based on additional data or logical arguments.
- Proposes, recognizes, analyzes, considers, and critiques alternative explanations; and distinguishes between fact and opinion.
- Identifies problems; proposes and implements solutions; and evaluates the accuracy, design, and outcomes of investigations.
- Works individually and in teams to collect and share information and ideas.

**Examples of activities through which students might demonstrate skill in scientific thinking include:**

Evaluate the claims and potential benefits and risks of steroid use and apply the scientific evidence to a reported “case study” of an athlete. 5a, 5b, 5c, 5d

Predict how long a plant will live, planted in moist soil in a closed glass jar located by a window; explain what additional information would be needed to make a better prediction. 5a, 5b, 5c

Compare and contrast the nutritional value of several common brands of cereals. 5b, 5c, 5d

Compare and contrast lines of evidence for theories of dinosaur extinction. 5b, 5c, 5d, 2c, 2d

Explain the chain of inference in DNA testing and debate both positions regarding its inclusion as evidence in a capital trial. 5c, 5d, 1b, 1c, 2a, 2b, 4d

$6$ **Scientific Tools and Technologies**

The student demonstrates competence with the tools and technologies of science by using them to collect data, make observations, analyze results, and accomplish tasks effectively; that is, the student:

- Uses technology and tools (such as traditional laboratory equipment, video, and computer aids) to observe and measure objects, organisms, and phenomena, directly, indirectly, and remotely, with appropriate consideration of accuracy and precision.
- Records and stores data using a variety of formats, such as data bases, audiotapes, and videotapes.
- Collects and analyzes data using concepts and techniques in Mathematics Standard 4, such as mean, median, and mode; outcome probability and reliability; and appropriate data displays.
- Acquires information from multiple sources, such as print, the Internet, computer data bases, and experimentation.
- Recognizes and limits sources of bias in data, such as observer and sample biases.

**Examples of activities through which students might demonstrate competence in the tools and technologies of science include:**

Work with other students to repeat a historical series of experiments, such as those leading to the current understanding of photosynthesis, and write an essay comparing and contrasting the differences in available tools and technologies. 6d, 2a, 4d, 4e, 5c, 7b

Evaluate the accuracy and timeliness of information reported during the “life” of a hurricane or tropical storm. 6d, 3a, 4a, 5c

Use the Internet to get current information on a rapidly changing scientific topic. 6d

Use a computer interface to measure the velocity of objects. 6d, 1d, 5c

Use telecommunications to compare data on similar investigations with students in another state. 6d

Earn the Orienteering Merit Badge (Boy Scouts of America) and teach another student what to do if he or she gets lost. 6d, 3a, 5c, 7d
Scientific Communication

The student demonstrates effective scientific communication by clearly describing aspects of the natural world using accurate data, graphs, or other appropriate media to convey depth of conceptual understanding in science; that is, the student:

- Represents data and results in multiple ways, such as numbers, tables, and graphs; drawings, diagrams, and artwork; technical and creative writing; and selects the most effective way to convey the scientific information.
- Argues from evidence, such as data produced through his or her own experimentation or data produced by others.
- Critiques published materials, such as popular magazines and academic journals.
- Explains a scientific concept or procedure to other students.
- Communicates in a form suited to the purpose and the audience, such as by writing instructions that others can follow; critiquing written and oral explanations; and using data to resolve disagreements.

Examples of activities through which students might demonstrate competence in scientific communication include:

- Analyze a ballot initiative on a local endangered species. 7a, 7b, 2c, 4d, 5a
- Critique a Time article which reports on something you have studied. 7c
- Make a "claymation" video illustrating in simple terms how a virus attacks the human body. 7a, 2d, 4c, 5c
- Give an oral report describing the change over time in local air quality. 7d, 2d, 3e, 4d, 5a
- Earn the Model Design and Building Merit Badge (Boy Scouts of America) and explain what constitutes an effective model. 7d, 4b, 5c
- Write an advertisement for a cold relief product that explains how it works. 7a, 4c, 5c, 5d, 6d

Scientific Investigation

The student demonstrates scientific competence by completing projects drawn from the following kinds of investigation, including at least one full investigation each year and, over the course of high school, investigations that integrate several aspects of Science Standards 1 to 7 and represent all four of the kinds of investigation:

- Controlled experiment.
- Fieldwork.
- Design.
- Secondary research.

A single project may draw on more than one type of investigation. A full investigation includes:

- Questions that can be studied using the resources available.
- Procedures that are safe, humane, and ethical; and that respect privacy and property rights.
- Data that have been collected and recorded (see also Science Standard 6) in ways that others can verify, and analyzed using skills expected at this grade level (see also Mathematics Standard 4).
- Data and results that have been represented (see also Science Standard 7) in ways that fit the context.
- Recommendations, decisions, and conclusions based on evidence.
- Acknowledgment of references and contributions of others.
- Results that are communicated appropriately to audiences.
- Reflection and defense of conclusions and recommendations from other sources and peer review.

Examples of projects through which students might demonstrate competence in scientific investigation include:

- Investigate the effectiveness of common household cleaners on bacterial growth. 8a, 1c, 2a, 4c
- Conduct research to determine if the incidence of asthma is related to weather. 8b, 3a, 4c
- Conduct a study of the geology of an area near the school and describe the likely history of the region, using observations and reference materials. 8b, 8a, 3a, 6d
- Compare and contrast the designs of different sports shoes and evaluate the designs considering the varying demands of different sports. 8c
- Conduct an investigation to determine if the shape of a stereo speaker container affects sound quality. 8a, 1f
- Study the distribution of a species in the region or state and discuss the likelihood of it becoming endangered. 8d, 2b, 5c, 6c
Work Sample & Commentary: Density of Sand

The task
This work sample was an entry in a Golden State Examination Science Portfolio for the category “problem solving investigation.” Students were required to submit a piece of work and the “Self-Reflection Sheet.” In this case, the student designed and conducted an investigation to determine the density of sand.

Circumstances of performance
This sample of student work was produced under the following conditions:

- alone
- in a group
- in class
- as homework
- with teacher feedback
- with peer feedback
- timed
- opportunity for revision

The work was done with a partner and written up individually.

What the work shows

S1b Physical Sciences Concepts: The student produces evidence that demonstrates understanding of the structure and properties of matter.

A B C Throughout the work, the student explained the relationship between mass, volume, and density, often with a level of detail revealing excellent conceptual understanding. There is also ample evidence that the student appreciated the relevance of density in everyday situations.

This work sample illustrates a standard-setting performance for the following parts of the standards:

S1b Physical Sciences Concepts: Structure and properties of matter.
S5a Scientific Thinking: Frame questions to distinguish cause and effect; and identify or control variables.
S5e Scientific Thinking: Evaluate the accuracy, design, and outcomes of investigations.
S7e Scientific Communication: Write instructions that others can follow.

The Density of Sand

**Purpose:** To determine the density of a sample of sand with air around the sand grains and then the density of the sand alone.

**Procedure:**
1. Record
   - Find mass of sand + cup
   - Find mass of empty cup
   - Subtract the mass of the empty cup from the mass of the sand + the cup. The result is the mass of the sand...
   - Put sand in a graduated cylinder, note volume.
   - Remove sand, put 80 ml water in graduated cylinder.
   - Add sand to water, note volume of sand + water.
   - Subtract the volume of the water (80 ml) from the volume of the water + the sand. The result is the volume of the sand...

**Data:**

<table>
<thead>
<tr>
<th>Mass of sand + cup (g)</th>
<th>Mass of cup (g)</th>
<th>Mass of sand (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>17.30</td>
<td>1.85</td>
<td>15.45</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Volume of water + sand (ml)</th>
<th>Volume of water(ml)</th>
<th>Volume of sand with air</th>
</tr>
</thead>
<tbody>
<tr>
<td>28.0</td>
<td>20.0</td>
<td>8.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Volume of with air</th>
<th>Density with air</th>
<th>Density without air</th>
</tr>
</thead>
<tbody>
<tr>
<td>18.4 ml</td>
<td>1.01 g/ml</td>
<td>1.08 g/ml</td>
</tr>
<tr>
<td>10.4 ml</td>
<td>1.94 g/ml</td>
<td>3.0 g/ml</td>
</tr>
</tbody>
</table>

S5a Scientific Thinking: The student identifies problems; proposes and implements solutions; and evaluates the accuracy, design, and outcomes of investigations.

E F G The student continually evaluated and critiqued the appropriateness of the experimental design and the accuracy of the measuring process, and described the situations in which the techniques employed would be most effective.
Calculations and Analysis:

1. The density of the sand with air was found to be 1.48 g/mL, and the density of the sand alone was 2.86 g/mL. The sand with air had a lower density than the sand alone because it contained air.

2. The density of the sand with air was found to be 1.48 g/mL, and the density of the sand alone was 2.86 g/mL. The sand with air had a lower density than the sand alone because it contained air.

3. The student's work involved individually and in teams to collect and share information. Three out of the four groups conducted experiments that had similar results to our own. One group's results were not consistent with the others, but the discrepancy was due to a misunderstanding of the procedure. By double-checking each group's measurements and calculations, it would be possible to determine which group had made the most accurate results.

4. The procedure utilized in this lab would work well for small, irregular solids such as sand. However, it would be too large to measure a graduated cylinder of volume X mL, and the density of regular solids would be underestimated. It would also be more accurate to determine the density of regular solids using a balance and a ruler.

5. The student has acknowledged the benefits of collaboration, and the use of technology and tools has been effective for judging accuracy. The student's work on this investigation was the result of a collaborative effort between the student and the investigator.

6. The purpose of this experiment is to determine the density of sand with air.

7. The student communicated in a form suited to the purpose and the audience, such as by writing instructions that others can follow.

8. The student used traditional methods and understood them.

Density of Sand

**Scientific Thinking:** The student works individually and in teams to collect and share information.

**Comparison of results among groups provided partial confirmation of results.**

**The student has acknowledged the benefits of collaboration.**

**Scientific Tools and Technologies:** The student uses technology and tools (such as traditional laboratory equipment) to measure objects directly, indirectly, and with appropriate consideration of accuracy and precision.

**Scientific Communication:** The student communicates in a form suited to the purpose and the audience, such as by writing instructions that others can follow.

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**GSE Self-reflection Sheet:** Problem-solving Investigation

1. Thoroughly explain the scientific concept you are investigating in this entry. Give specific examples that demonstrate how the concept applies to your problem-solving investigation.

2. Describe, in detail, the part or parts of this investigation you particularly designed.

3. Describe how the scientific concept you investigated in this entry is related to a real-world issue or personal experience you may have.

4. Describe how working with others on this investigation helped to increase your understanding of the scientific concept.

5. What did you conclude from the investigation? Was the conclusion the same as or different from what you expected? Describe how your observations and data support your conclusions.

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From this investigation, we concluded that a sample of sand has a lower density than when it is surrounded by air. Sand without air had a density of 2.86 g/mL, whereas sand that was surrounded by air had a density of 1.48 g/mL. This experiment was an interesting way to discover that the presence or absence of air affects the density of a substance. This is a phenomenon we observed in our calculations of the density of the sand with air and without air. By comparing our results with those of other lab teams, we concluded that density is an important property. Although some of the values used in our calculations may have varied, the results were similar and the concept remains consistent with our observations.
Work Sample & Commentary: Photosynthesis

The task
This work sample was an entry in a Golden State Examination Science Portfolio for the category “Problem-solving investigation.” Students were required to submit a piece of work and the “Self-Reflection Sheet.” In this case, the student designed and conducted an investigation of the factors that affect the rate of photosynthesis.

Circumstances of performance
This sample of student work was produced under the following conditions:

- alone
- in class
- with teacher feedback
- timed

in a group
as homework
with peer feedback
opportunity for revision

The work was done with a partner and written up individually. It followed a unit on biochemistry and photosynthesis.

What the work shows

51c Physical Sciences Concepts: The student produces evidence that demonstrates understanding of chemical reactions, such as...electrons, protons, and energy transfer....

A B In his descriptions of photosynthesis, the student explained the chemical reactions and interactions of energy and matter, often with sophisticated detail. This understanding is evident throughout the work.

51f Physical Sciences Concepts: The student produces evidence that demonstrates understanding of interactions of energy and matter, such as waves, absorption and emission of light, and conductivity.

C Here and elsewhere, the work shows evidence of understanding the interactions of matter and energy through the discussion of wavelengths of light. An alternative or additional explanation for the high rate of photosynthesis for the white light is that all of the colored filters reduced the intensity of the light, meaning that fewer photons reached the leaf. There is no mention of the intensity of the light, but from the description of the procedure it is unlikely that this variable was not controlled.
Life Sciences Concepts: The student produces evidence that demonstrates understanding of the cell, such as cell structure and function relationships; regulation and biochemistry; and energy and photosynthesis.

D In describing what happens in the chloroplast of the cell, the work shows evidence of understanding the structure and function relationships inside the cell. The entire piece of work demonstrates understanding of photosynthesis.

Life Sciences Concepts: The student produces evidence that demonstrates understanding of matter, energy, and organization in living systems, such as energy flow through different levels of organization; and environmental constraints.

E F The explanation of the flow of energy offers evidence of sophisticated understanding of the dynamic process whereby plants produce energy and other organisms rely on that energy for survival.

G The phrase “energy rich ATP and NADPH” appears above and adjacent to the cell drawing. It is true that NADPH has reducing power, but it is not an energy source, although ATP is.
Photosynthesis

55a Scientific Thinking: The student frames questions to distinguish cause and effect; and identifies or controls variables in experimental and non-experimental research settings.

M Here and throughout, the work displays evidence of appropriate scientific thinking and use of experimental data to reach conclusions.

56a Scientific Tools and Technologies: The student uses technology and tools (such as traditional laboratory equipment, video, and computer aids) to observe and measure objects, organisms, and phenomena directly, indirectly, and remotely; and with appropriate consideration of accuracy and precision.

Appropriate tools and technologies are used effectively and procedures are executed thoughtfully.

57a Scientific Communication: The student represents data and results in multiple ways, such as numbers, tables, and graphs; drawings, diagrams, and artwork; technical and creative writing; and selects the most effective way to convey the scientific information.

Throughout the work, multiple representations (e.g., graphs, diagrams, and text) are effectively employed to enhance the communication of the scientific concepts.
Work Sample & Commentary: Bio-poem

The task
Students in a high school biology class were asked to write a bio-poem about something they had learned. The biographical form required the students to include in their poems specific statements about characteristics, siblings, and needs.

Circumstances of performance
This sample of student work was produced under the following conditions:

- alone
- in a group
- in class
- as homework
- with teacher feedback
- with peer feedback
- timed
- opportunity for revision

This task resulted from a series of assignments which allowed the students to express the relationships between living things in creative ways.

What the work shows

52a Life Sciences Concepts: The student produces evidence that demonstrates understanding of the cell, such as cell structure and function relationships;... and energy and photosynthesis.

A

52e Life Sciences Concepts: The student produces evidence that demonstrates understanding of matter, energy, and organization in living systems, such as matter and energy flow through different levels of organization....

B The student clearly identified the needs of plants and displayed understanding of the flow of energy between levels (plants to heterotrophs).

54a Scientific Connections and Applications: The student produces evidence that demonstrates understanding of big ideas and unifying concepts, such as order and organization;... change and constancy...

The student demonstrated a complex understanding of biology throughout the work. By relating genetics and reproduction to the physiological needs of the plant and the products of photosynthesis, the student integrated many important ideas of science.

57d Scientific Communication: The student explains a scientific concept or procedure to other students.

C Using the bio-poem form, the student correctly explained several complex concepts related to plants. These concepts are complex to explain in simple language. In producing this type of poem the student demonstrated a deep understanding of the needs of, desirable conditions for, and energy flow through plants.

The use of “sibling” with respect to mitosis is a consequence of the literary form, not a misunderstanding of mitosis.

This work sample illustrates a standard-setting performance for the following parts of the standards:

52a Life Sciences Concepts: The cell.
52e Life Sciences Concepts: Matter, energy, and organization in living systems.
54a Scientific Connections and Applications: Big ideas and unifying concepts.
57d Scientific Communication: Explain a scientific concept or procedure to other students.

The quotations from the Science performance descriptions in this commentary are excerpted. The complete performance descriptions are shown on pages 82-85.
Work Sample & Commentary: Erosion on the Minnehaha Creek

The task
The National Student Research Center (NSRC) encourages the establishment of student research centers in schools in the United States and around the world. The Center facilitates the exchange of information by publishing a journal of student investigations and by use of the Internet (nsrcmms@aol.com). It provides a standard format that students use to report their results. The format requires that students state a purpose and hypothesis; report their methods, data analysis, and conclusions; and suggest applications for their results.

Circumstances of performance
This sample of student work was produced under the following conditions:
- alone
- in class
- with teacher feedback
- timed
- in a group
- as homework
- with peer feedback
- opportunity for revision

What the work shows

S3 Earth and Space Sciences Concepts: The student produces evidence that demonstrates understanding of natural resource management.

A The student produced a list of hypotheses which is really a list of explanations that give evidence of conceptual understanding of the mechanisms of erosion.

B Scientific Thinking: The student frames questions to distinguish cause and effect; and identifies or controls variables in experimental and non-experimental research settings.

C The work shows that a number of steps were taken to measure erosion, although the Erosion Index that plays a critical role in the study is not explained. However, there is detailed evidence that most of the critical variables were identified and controlled.

S5b Scientific Thinking: The student uses concepts from Standards 1 to 4 to explain a variety of observations and phenomena.
Erosion on the Minnehaha Creek

Scientific Thinking: The student uses evidence from reliable sources to develop descriptions [and] explanations; and makes appropriate adjustments and improvements based on additional data or logical arguments.

D The explanation of erosion control factors and probability is strong evidence of this student using data from the field study to reach a defensible conclusion.

Scientific Thinking: The student distinguishes between fact and opinion.

D The student explained the mathematical basis upon which he built his conclusion.

Scientific Thinking: The student identifies problems; proposes solutions....

E F The work shows that the student identified and defined the problem and used data to back up the conclusions, recommending a practice to solve part of the problem.

Scientific Thinking: The student works individually and in teams to collect and share information and ideas.

Scientific Tools and Technologies: The student uses technology and tools (such as traditional laboratory equipment...) to observe and measure objects, organisms, and phenomena, directly, indirectly, and remotely, with appropriate consideration of accuracy and precision.

The student displayed attention to accuracy and precision by including the following steps: deciding on a representative sample, developing an observation form with help from experts, training independent observers, and taking observations from both sides of the creek.
**Work Sample & Commentary:** Are Oysters Safe to Eat?

The task
The National Student Research Center (NSRC) encourages the establishment of student research centers in schools in the United States and around the world. The Center facilitates the exchange of information by publishing a journal of student investigations and by use of the Internet (nsrcmms@aol.com). It provides a standard format that students use to report their results. The format requires that students state a purpose and hypothesis; report their methods, data analysis, and conclusions; and suggest applications for their results.

Circumstances of performance
This sample of student work was produced under the following conditions:

- alone
- in class
- with teacher feedback
- timed
- as homework
- with peer feedback opportunity for revision

What the work shows
52d Life Sciences Concepts: The student produces evidence that demonstrates understanding of interdependence of organisms such as cooperation and competition among organisms in ecosystems....

This work sample illustrates a standard-setting practice for the following parts of the standards:

- 52e Life Sciences Concepts: Matter, energy, and organization in living systems.
- 54c Scientific Connections and Applications: Health, personal and environmental safety.
- 55a Scientific Thinking: Frame questions to distinguish cause and effect; and identify or control variables.
- 55b Scientific Thinking: Use concepts from Standards 1 to 4 to explain observations and phenomena.
- 55c Scientific Thinking: Use evidence from reliable sources.
- 55d Scientific Thinking: Distinguish between fact and opinion.
- 56a Scientific Tools and Technologies: Use technology and tools.
- 56d Scientific Tools and Technologies: Acquire information from multiple sources.
- 58a Scientific Investigation: Controlled experiment.

A Many animals and bacteria live in cooperation. The identification of bacterial forms that are naturally found in waters with oysters demonstrates understanding of this relationship.

B The use of agar as a growth medium and the identification of the need for sterile equipment provide evidence of understanding how bacteria grow as well as the importance of appropriate scientific procedures.

C The student related the rate of bacteria growth to temperature and season.

54c Scientific Connections and Applications: The student produces evidence that demonstrates understanding of...organization in living systems, such as...environmental constraints.

The student offered two types of warnings regarding bacteria and oysters.
Are Oysters Safe to Eat?

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IV. SUMMARY AND CONCLUSION:

A series of experiments demonstrated the amount of bacteria present in oysters. Students sampled oysters from multiple locations and were able to identify several species of bacteria. The results showed that bacteria levels were highest in oysters from coastal areas, particularly during the summer months.

V. APPLICATION:

Students can use this information to create a model that predicts the risk of bacterial contamination in oysters. They can also use the data to create a report that outlines the steps needed to reduce the risk of bacterial contamination in oysters.

The student researcher used permission of the National Student Research Center, Dr. John I. Swang, Mandeville Middle School, 2025 South Street, Mandeville, Louisiana 70448, 504-626-6569. or nanorms@iac.com.

The first gives a method to reduce risk of bacterial infection significantly. The second indicates different levels of risk by season. Both provide evidence of the quality of work expected at the high school level.

55 a Scientific Thinking: The student frames questions to distinguish cause and effect; identifies and controls variables in experimental...research settings.

55 b Scientific Thinking: The student uses concepts from Science Standards 1 to 4 to explain a variety of observations and phenomena.

55 c Scientific Thinking: The student uses evidence from reliable sources to develop descriptions, explanations...and makes appropriate adjustments and improvements based on additional data or logical arguments.

55 d Scientific Thinking: The student distinguishes between fact and opinion.

56 a Scientific Tools and Technologies: The student uses technology and tools (such as traditional laboratory equipment)...with appropriate consideration of accuracy and precision.

56 b Scientific Tools and Technologies: The student acquires information from multiple sources, such as print, the Internet...and experimentation.

The report is not explicit about how the bacteria were identified. Identifying bacteria is sophisticated work for a high school student. Assistance would have been appropriate (and should have been acknowledged).

58 a Scientific Investigation: The student demonstrates scientific competence by completing a controlled experiment. A full investigation includes:

- Questions that can be studied using the resources available.
- Procedures that are safe, humane, and ethical; and that respect privacy and property rights.
- Data that has been collected and recorded (see also Science Standard 6) in ways that others can verify, and analyzed using skills expected at this grade level (see also Mathematics Standard 4).
- Data and results that have been represented (see also Science Standard 7) in ways that fit the context.
- Recommendations, decisions, and conclusions based on evidence.

The student, as part of the NSRC format, loaded this work up onto the Internet for peer review. It is not stated whether this review informed the final report.
The task
Students were asked to write a report on the benefits and risks of common medications. This student compared three medications: aspirin, acetaminophen, and ibuprofen.

Circumstances of performance
This sample of student work was produced under the following conditions:

- alone
- in class
- with teacher feedback
- timed

in a group
as homework
with peer feedback
opportunity for revision

What the work shows

§2 Life Sciences Concepts: The student produces evidence that demonstrates understanding of behavior of organisms, such as nervous system regulation....

A The discussion of the effects of aspirin demonstrates understanding of homeostatic mechanisms on clotting and bleeding.

B The connection between overdose and effects on the central nervous system clearly shows conceptual understanding of system control, maintenance, and the benefits and risks of medication.

C The understanding that human systems are regulated by the production of specific chemicals is consistently demonstrated throughout this work.

§4 Scientific Connections and Applications: The student produces evidence that demonstrates understanding of health, such as...disease...; personal and environmental safety....

D E Understanding of health is evident throughout this piece. For example, the distinction between curing ailments, reducing pain and fever, and the summary of the three medications shows understanding as well as detail.

§7 Scientific Communication: The student represents data and results in multiple ways, such as...technical and creative writing.

The interview format is a creative way to provide a great amount of detail. This form requires the student to have a great deal of background knowledge and adequate understanding of the underlying concepts in order to present the information accurately.
Scientific Communication: The student argues from evidence, such as data produced through his or her own experimentation or...by others.

The work covers a range of information from uses to benefits and risks, giving a complete explanation and summary from varied sources. It does not consider the biases of these sources of information and this (apparently) uncritical acceptance of the information is a shortcoming of the piece.

Scientific Communication: The student explains a scientific concept or procedure to other students.

The construction of the interview questions frames the topic in a way that allows an explanation of each medication to be given in depth. Careful attention to detail in the discussion of the effects of overdoses and how aspirin chemically blocks pain provides the clarity necessary to illustrate this part of the student's work.

Scientific Communication: The student communicates in a form suited to the purpose and the audience....

The format for the comparison, an interview with each of the pain relievers, is an effective way of presenting information that could be tedious to read if presented in a traditional report. However, the format limits the depth of conceptual understanding that is demonstrated.
Interview With Aspirin

E2 Writing: The student produces a report that:
- engages the reader by establishing a context, creating a persona, and otherwise developing reader interest;
- develops a controlling idea that conveys a perspective on the subject;
- creates an organizing structure appropriate to purpose, audience, and context;
- includes appropriate facts and details;
- excludes extraneous and inappropriate information;
- uses a range of appropriate strategies, such as providing facts and details, describing or analyzing the subject, narrating a relevant anecdote, comparing and contrasting, naming, explaining benefits or limitations, demonstrating claims or assertions, and providing a scenario to illustrate;
- provides a sense of closure to the writing.

The work is presented within the controlling idea of a series of interviews.

The reader's interest is engaged through the establishment of three independent personas in a familiar "interview-with-a-celebrity" format.

C The organizing structure of the interviews allowed the student to convey information to his teacher and fellow students in an interesting and memorable fashion.

The three sections, for the most part, include parallel facts and details, allowing for a useful comparison among the three pain relievers.

E The student provided a clear sense of closure by summarizing the benefits and risks of three common medications.
Work Sample & Commentary: A Geographical Report

The task
Students were assigned to write a report for science class using at least five sources, only two of which could be encyclopedias. They were encouraged to include clarifications or illustrations of key points and a complete bibliography.

Circumstances of performance
This sample of student work was produced under the following conditions:
- alone
- in class
- with teacher feedback
- as homework
- with peer feedback
- opportunity for revision

What the work shows

52 d Life Sciences Concepts: The student produces evidence that demonstrates understanding of the interdependence of organisms, such as cooperation and competition among organisms in ecosystems; and human effects on the environment.

A The student pointed out the necessity of having rabbits at the vernal pools to eat and then spread the seeds of digested plants.

B The pressure placed on this ecosystem is noted in the initial question.

C The student offered further explanation of human impact on this ecosystem.

D The student made suggestions to minimize the damage caused by development.

53 e Earth and Space Sciences Concepts: The student produces evidence that demonstrates understanding of natural resource management.

F The student constructed a strong argument for the protection of the vernal pools.

55 a Scientific Thinking: The student frames questions to distinguish cause and effect.

55 b Scientific Thinking: The student uses concepts from Science Standards 1 to 4 to explain observations and phenomena.

57 a Scientific Communication: The student uses concepts from Science Standards 1 to 4 to explain a variety of observations and phenomena.

I The student used conceptual information here and throughout the work to explain the pools and to develop the view of these wetlands as a geographical asset.

The quotations from the Science performance descriptions in this commentary are excerpted. The complete performance descriptions are shown on pages 82-85.

The standards for middle school are set at a level of performance approximately equivalent to the end of eighth grade and for high school at the end of tenth grade. It is expected that some students might achieve these levels earlier and others later than these grades. It is the expected quality of work rather than the age or grade of the student that governs the selection of work to illustrate the standards. This work sample appears in New Standards Performance Standards Volume 2 to illustrate a standard-setting performance for writing a report for the English Language Arts standard of the middle school level. The conceptual understanding in science, however, is at the level expected for high school. Thus, we have included the piece again here despite the age or grade of the student who produced it.
A Geographical Report

**Scientific Thinking: The student uses evidence from reliable sources to develop descriptions, explanations...**

**J** The student did not limit the work to what could be found at public libraries, but conducted interviews and a significant literature search to find the information needed.

**Scientific Thinking: The student proposes, recognizes, analyzes, considers, and critiques alternative explanations; and distinguishes between fact and opinion.**

Consideration of alternative explanations or solutions is not evident in the text itself, but the depth and breadth of the bibliography suggest that the work took into account a diversity of ideas.

**Scientific Communication: The student represents data and results in multiple ways, such as...graphs; drawings, diagrams, and artwork; technical...writing; and selects the most effective way to convey the scientific information.**

The student used a combination of clear writing, diagrams, and references to other portions of the work to clearly communicate the structure and cycles of these pools.

**L M N** The diagrams are particularly effective.
A Geographical Report

The student explained a scientific concept to other students.

Throughout the work, the text succeeds in explaining and persuading.

Science Communication: The student communicates in a form suited to the purpose and the audience.

Science Investigation: The student demonstrates scientific competence by completing a design project.

Science Investigation: The student demonstrates scientific competence by completing a secondary research project.

A full investigation includes:

- Questions that can be studied using the resources available.
- Procedures that are safe, humane, and ethical; and that respect privacy and property rights.
- Data that have been collected and recorded (see also Science Standard 6) in ways that others can verify, and analyzed using skills expected at this grade level (see also Mathematics Standard 4).

Throughout the work, the student left a clear path for another student to follow in order to replicate the investigation or verify the conclusions.

- Data and results that have been represented (see also Science Standard 7) in ways that fit the context.
- Recommendations, decisions, and conclusions based on evidence.

The student argued from evidence to draw conclusions and make recommendations in a way that is focused and coherent.

- Acknowledgment of references and contributions of others.

Results that are communicated appropriately to audiences.

Reflection and defense of conclusions and recommendations from other sources and peer review.

Peer review is not included in the work. However, the extensive communication with experts shows that the conclusions were informed, in part, with the help of iterative external review.
A Geographical Report

The first step is to try to keep development away from natural pools. But to do this you need to know where these pools are. Thanks to recent mapping efforts, nearly all natural pools have been fairly well identified in the region.

There are already some arguments against natural pools. You could go farther and find that a large body of water is a natural asset. The U.S. Fish and Wildlife Service promotes the need for undisturbed natural pools, and the U.S. Army Corps of Engineers makes sure you don’t just add to the already existing habitat. Natural pools are important to wildlife conservation, and should be protected by a banner of cleanliness. Passage of water can be just as deadly to the natural pools as it can to people, and it is important to educate people about natural pools so they know their importance and what they can do to save them.

A common argument is that natural pools do not provide recreation. People would want to have the pools and skills adapted to the natural environment. This would mean protecting the natural features of natural pools, not just the water. Therefore, people can be protected by passing a barrier or fence. The natural environment could be used as an added educational opportunity for the general public. The pools become an educational tool for water features, which can be incorporated in the natural world. The pools could be used to introduce new native species, with native animals to research the models, to help the local populations in understanding their environment. (More Information)

CONCLUSION

The statement that natural pools do not provide recreation is false. Natural pools can be used as educational tools for understanding the environment. People would want to keep the natural pools and skills adapted to the natural environment. This would mean protecting the natural features of natural pools, not just the water. Therefore, people can be protected by passing a barrier or fence. The natural environment could be used as an added educational opportunity for the general public. The pools become an educational tool for water features, which can be incorporated in the natural world. The pools could be used to introduce new native species, with native animals to research the models, to help the local populations in understanding their environment. (More Information)
A Geographical Report

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Senior research analyst, SANDAG (San Diego Association for Planning and Environmental Protection), January 1979.

Director of Biological Services, RECON (Regional Environmental Consultants), December 4, 1979.


Senior Planner, City of San Diego, Environmental Services, December 7, 1994.

ACKNOWLEDGMENTS

I would like to thank the Library at the University of San Diego for supplying the invaluable information and help. I would also like to thank all the people who helped me with this project, especially Mr. Smith for his help and Mr. Johnson for his patience.

I would like to thank Mr. Johnson for his patience and Mr. Smith for his help. I would also like to thank all the people who helped me with this project, especially Mr. Smith for his help and Mr. Johnson for his patience.
The task
Students were asked to design and conduct an experimental project that would improve the environment at their high school. The assignment, given to students in an environmental science class, followed a unit on the chemistry and biology of ground and water pollution.

Circumstances of performance
This sample of student work was produced under the following conditions:

- alone
- in class
- with teacher feedback
- timed
- in a group
- as homework
- with peer feedback
- opportunity for revision

What the work shows

S2 d Life Sciences Concepts: The student produces evidence that demonstrates understanding of the interdependence of organisms, such as... cooperation and competition among organisms in ecosystems...

A B The work shows understanding of the interdependence of organisms, including populations, ecosystems, and food webs.

S4 a Scientific Connections and Applications: The student produces evidence that demonstrates understanding of the big ideas and unifying concepts, such as... models, form and function; change and constancy; and cause and effect.

C The compost bottle was a small scale model in which the variables could be controlled, then scaled up to the compost pile recommended in the conclusions.

D The discussion of the earwigs' niche shows an understanding of the interdependence of growth, population stress, and predator/prey relationships, all evidence of an understanding of change and constancy, and of cause and effect.

S6 a Scientific Tools and Technologies: The student uses technology and tools (such as traditional laboratory equipment...) to observe and measure...organisms and phenomena, directly....

E The students created the tools to make this investigation possible, overcoming the obstacle and impracticality of two full-size compost piles.

S6 d Scientific Tools and Technologies: The student acquires information from multiple sources such as print... and experimentation.

B D

This work sample illustrates a standard-setting performance for the following parts of the standards:

S2 d Life Sciences Concepts: Interdependence of organisms.
S4 a Scientific Connections and Applications: Big ideas and unifying concepts.
S6 a Scientific Tools and Technologies: Use technology and tools.
S6 d Scientific Tools and Technologies: Acquire information from multiple sources.
S7 a Scientific Communication: Represent data and results in multiple ways.
S8 a Scientific Investigation: Controlled experiment.
Compost

Scientific Communication: The student represents data and results in multiple ways, such as drawings, and technical writing.

The precision of the language, “we believe to be fungi” and “possibly mites,” is excellent.

Drawings are used effectively.

Scientific Investigation: The student demonstrates scientific competence by completing a controlled experiment. A full investigation includes:

- Questions that can be studied using the resources available.
- The work shows consideration of appropriate resources by scaling down the compost pile to conduct the investigation accurately and practically in a pop bottle.
- Procedures that are safe, humane, and ethical; and that respect privacy and property rights.

The work also shows attention to safety and consideration for others.

Data that have been collected and recorded (see also Science Standard 6) in ways that others can verify, and analyzed using skills expected at this grade level (see also Mathematics Standard 4).

This work shows thorough and appropriate documentation, both in the procedures and in the descriptions of the organisms that provide enough detailed information for others to replicate the investigation.

- Data and results that have been represented (see also Science Standard 7) in ways that fit the context.

The writing contains some spelling and grammatical errors, but these do not detract from the quality of the report.

- Recommendations, decisions, and conclusions based on evidence.
- The conclusion is drawn from evidence.
- Acknowledgment of references and contributions of others.
- Results that are communicated appropriately to audiences.

The conclusion of the report is an appropriate recommendation to the school principal, “Mr. W.,” as to where the school should keep a compost pile.

- Reflection and defense of conclusions and recommendation from other sources and peer review.

Evidence of peer review is not included in this report.