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s on the western movement and how it w
s to go coast to coast. He later named thi
. His theory involved six groups of people
ermed "waves". There were many people w
as he right, or was he wrong?
d deal of evidence leading up to him being
were: Fur Traders, Cattlemen, Pioneer Fa
mers, and Specialist\ Urban Settlers. One
p of six to settle in the West were the F
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e Fur Traders and was well known. On the
Kentucky, they brought with them coonsk
ders helped settle Tennessee. The next gr
stretched as far as San Diego to San Fra
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found in the West, especially in Californ
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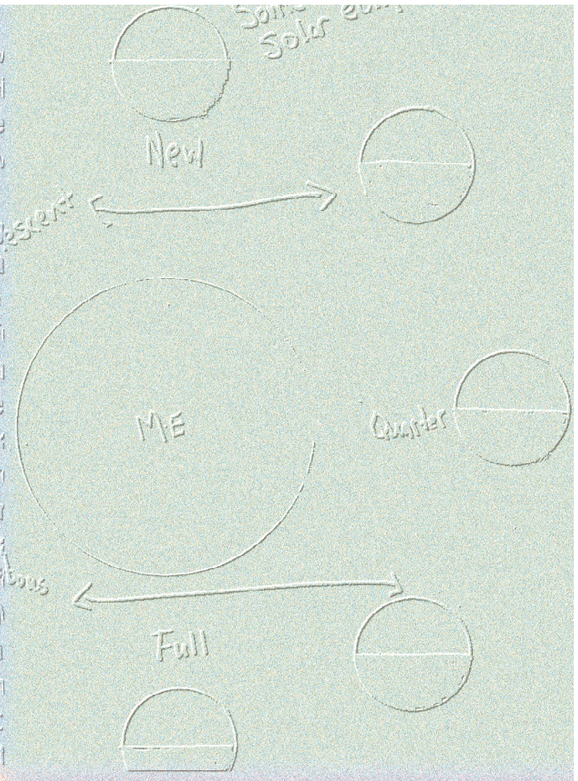
fortune in gold in California. This made



Make a circle diagram with dia
explain your solution in words

Step 1: Fr

$A = \pi r^2$

Evaluation of Career Day

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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 page 101), and "The Density of Sand" at the high school level (see Volume 3, 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, S6 , 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 50% 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.

To see how these performance descriptions compare with the expectations for elementary school and high school, turn to pages 158-165.

The Science standards are founded upon both the National Research Council's *National Science Education Standards* and the American Association for the Advancement of Science's Project 2061 *Benchmarks for Science Literacy*. These documents, each of which runs to several hundred pages, contain detail that amplifies the meaning of the terms used in the performance descriptions.

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:

S1 a Properties and changes of properties in matter, such as density and boiling point; chemical reactivity; and conservation of matter.

S1 b Motions and forces, such as inertia and the net effects of balanced and unbalanced forces.

S1 c Transfer of energy, such as transformation of energy as heat; light, mechanical motion, and sound; and the nature of a chemical reaction.

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

Use the concept of density to explain why some things float and others sink in water. **1a**

Investigate the characteristics that are necessary to obtain an electric current from an electrochemical cell of metal(s) and a fluid medium. **1a**

Explain the difference between recycling and reusing in terms of mass and energy conservation. **1a, 1c, 3a, 4b**

Use the concept of force to explain the roles of front and rear brakes on a bicycle. **1b, 4d**

Build a grandfather clock and explain how it works. **1b, 4d, 8c, A1a**

Conduct an energy audit of the classroom and develop procedures for reducing waste. **1c, 4a, 4b, A1b**

Evaluate the claims and potential benefits of sunglasses that are advertised to screen out ultraviolet light. **1c, 4a, 4b, 4c**

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:

S2 a Structure and function in living systems, such as the complementary nature of structure and function in cells, organs, tissues, organ systems, whole organisms, and ecosystems.

S2 b Reproduction and heredity, such as sexual and asexual reproduction; and the role of genes and environment on trait expression.

S2 c Regulation and behavior, such as senses and behavior; and response to environmental stimuli.

S2 d Populations and ecosystems, such as the roles of producers, consumers, and decomposers in a food web; and the effects of resources and energy transfer on populations.

S2 e Evolution, diversity, and adaptation of organisms, such as common ancestry, speciation, adaptation, variation, and extinction.

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

Explain the effects of a particular disease (e.g., common cold) on an organism's internal structures and their related functions. **2a, 4a, 4c**

Use drawings to demonstrate the structure and function relationships among a group of cells, tissues, or organs. **2a, 2c**

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**

Write a story about how a person learned to overcome an inherited physical limitation. **2b, 4b**

Explain why offspring of organisms that reproduce sexually never look exactly like their parents. **2b, 2e**

Earn the Bird Study Merit Badge (Boy Scouts of America) or complete the Plant Culture Project (Girl Scouts of the U.S.A.) and explain how it helped you to understand animal behavior, ecology, or regulation. **2c, 2d, 2e, 4a**

Explain the physiology of sneezes, tears, or what happens when people laugh. **2c**

Identify a pest in the immediate environment; and use an understanding of food webs to propose and test a way to eliminate the pest without introducing environmental poisons. **2d, 2e, 1c, 4b, 4c, 4d, 4e**

Conduct an investigation to determine the kinds of seeds best suited to germination in a hydroponic system. **2a, 2d, 2e, 4b, 8a**

Explain the lines of evidence showing that dogs and cats are related by common ancestors. **2b, 2c, 4a, 5c**

Compare and contrast historical situations where species became extinct with situations where species survived due to differences in adaptive characteristics and the degree of environmental stress or change. **2b, 2c, 2d, 2e, 4a**

S3 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 Structure of the Earth system, such as crustal plates and land forms; water and rock cycles; oceans, weather, and climate.

S3 b Earth's history, such as Earth processes including erosion and movement of plates; change over time and fossil evidence.

S3 c Earth in the Solar System, such as the predictable motion of planets, moons, and other objects in the Solar System including days, years, moon phases, and eclipses; and the role of the Sun as the major source of energy for phenomena on the Earth's surface.

S3 d Natural resource management.

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

Explain how earthquakes, volcanoes, and sea-floor spreading have a common cause. **3a, 3b, 4a, 4c**

Write a story that describes what happens to a drop of water and the physical environment through which it flows as it travels from a lake to a river via the Earth's atmosphere. **3a, 3c, 1a, 4a**

Complete the Geology Project (Girl Scouts of the U.S.A.) or earn the Astronomy Merit Badge (Boy Scouts of America) and explain what it helped you to understand about Earth processes and structures; fossil evidence; or aspects of the Solar System. **3a, 3b, 3c**

Create a storybook to explain to a younger child how occasional catastrophes, such as the impact of an asteroid or comet, can influence the Earth's history. **3b, 3c, 2b, 2c, 2d, 2e**

Predict what will happen to the reading of your weight on a bathroom scale while riding in an elevator, investigate your predication, and explain why the prediction was or was not accurate. **3c, 1b**

Use the concept of gravity to explain why people can jump higher on the Moon than they can on Earth. **3c**

Identify a place that is subject to periodic flooding, evaluate its positive and negative consequences, and study different ways of maintaining, reducing or eliminating the likelihood of flooding. **3d**

S4 Scientific Connections and Applications

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:

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 nature of science and technology; the development of agricultural techniques; and the viability of technological designs.

S4 c Health, such as nutrition, exercise, and disease; effects of drugs and toxic substances; personal and environmental safety; and resources and environmental stress.

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:

Create a health pamphlet for a track team that travels around North America to help them adjust to altitudes different from the place where they usually train, and explain why these adjustments are necessary. **4a, 4d, 2c**

Develop a plan to modify the school's fire warning system for students with disabilities. **4b, 4d**

Analyze an automatic ice maker and explain how its design takes into account the differences in the properties of water in liquid and solid states. **4b, 4d, 1a**

Identify a pest in a local agricultural setting; and compare and contrast the risks and benefits of chemical and biological pest control. **4b, 4c, 4d, 4e, 2d**

Hypothesize why people tend to get more colds and flu in the winter and discuss ways to prevent the spread of illness. **4c, 2c**

Investigate local water quality standards and make recommendations to school officials about water quality on and near the campus. **4c, 3a, A1b**

Samples of student work that illustrate standard-setting performances for these standards can be found on pages 96-111.

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 middle 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.

S5 Scientific Thinking

The student demonstrates scientific inquiry and problem solving by using thoughtful questioning and reasoning strategies, common sense and conceptual understanding from Science Standards 1 to 4, and appropriate methods to investigate the natural world; that is, the student:

S5 a Frames questions to distinguish cause and effect; and identifies or controls variables in experimental and non-experimental research settings.

S5 b Uses concepts from Science Standards 1 to 4 to explain a variety of observations and phenomena.

S5 c Uses evidence from reliable sources to develop descriptions, explanations, and models.

S5 d Proposes, recognizes, analyzes, considers, and critiques alternative explanations; and distinguishes between fact and opinion.

S5 e Identifies problems; proposes and implements solutions; and evaluates the accuracy, design, and outcomes of investigations.

S5 f 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:

Investigate the results of two fellow students' plant growth experiments and recommend ways to enhance the information. **5a, 5b, 5c, 5d, 5e, 5f, 2a**

Determine if the scientific evidence in the summary data chart in Consumer Reports substantiates recommendations about the "Best Buy" for a particular purchase. **5a, 5b, 5c, 5d, 5e**

Work with another student to investigate the effects of several variables on oxygen production in an aquatic plant, e.g., nutrients, light, color of container. **5a, 5b, 5c, 5d, 5e, 5f, 2a, 2c**

Evaluate the claims and potential risks and benefits of a newly advertised "diet pill." **5b, 5c, 5d, 5e, 2c, 4c**

S6 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:

S6 a 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.

S6 b Records and stores data using a variety of formats, such as data bases, audiotapes, and videotapes.

S6 c 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.

S6 d Acquires information from multiple sources, such as print, the Internet, computer data bases, and experimentation.

S6 e Recognizes sources of bias in data, such as observer and sampling biases.

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

Use a microcomputer-based investigation to compare the rates at which different carbonated beverages in a variety of containers lose their fizz. **6a, 1a, 4b, 5a**

Complete the Animal Observation Project (Girl Scouts of the U.S.A.) and teach another student how to conduct field observations. **6a, 2d**

Conduct a field research project to compare the distribution of birds near the school with a field guide for the region to see if local distributions are the same as regional. **6c, 6d, 2d**

Compare the accuracy and timeliness of local weather information from a variety of sources. **6d, 3a**

Exchange data on the acidity of rain with students from other states or countries. Figure out why the data differ, if they do. **6d, 1a, 3a**

Use electronic data bases to get current information on the health effects of long-term space travel. **6d, 3c, 4c**

To see how these performance descriptions compare with the expectations for elementary school and high school, turn to pages 158-165.

The Science standards are founded upon both the National Research Council's *National Science Education Standards* and the American Association for the Advancement of Science's Project 2061 *Benchmarks for Science Literacy*. These documents, each of which runs to several hundred pages, contain detail that amplifies the meaning of the terms used in the performance descriptions.

S7 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:

S7 a Represents data and results in multiple ways, such as numbers, tables, and graphs; drawings, diagrams, and artwork; and technical and creative writing.

S7 b Argues from evidence, such as data produced through his or her own experimentation or by others.

S7 c Critiques published materials.

S7 d Explains a scientific concept or procedure to other students.

S7 e 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:

Earn the Drafting Merit Badge. (Boy Scouts of America) **7a, 4b, 5c, 6a**

Write an advertisement for a hair care product that explains the chemistry of how it works. **7b, 1a, 4b, 4c, 5d**

Analyze and give a speech about a ballot initiative on toxic chemicals. **7c, 1a, 2c, 3a, 4b, 5d, 6d**

Critique a *USA Today* article which reports that eating hot dogs in childhood causes adult leukemia. **7c, 2c, 4c, 5d**

Write a review of an episode of *Beakman's World*. **7c, 5d, 6d**

Make an animated video illustrating how white blood cells protect the body from infectious agents. **7d, 2a, 2c, 4c, 5c**

S8 Scientific Investigation

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

S8 a Controlled experiment.

S8 b Fieldwork.

S8 c Design.

S8 d Secondary research, such as use of others' data.

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:

Analyze de-icers for relative effectiveness, cost, and environmental impact. **8a, 1a, 3d, 4d**

Study different methods for cooking chicken considering health and aesthetics. **8a, 8c, 4c**

Conduct a field study of monument degradation over time at a local cemetery. **8b, 1a, 3a**

Adopt a stream and use that location to study habitat and water quality over time. **8b, 2d, 3a**

Design a protective container for an uncooked egg using the concepts of force, motion, gravity, and acceleration and test the design by dropping the container (egg enclosed) from a one-story building. **8c, 1a, 1b**

Research local climate changes over the last century. **8d, 3a**

Samples of student work that illustrate standard-setting performances for these standards can be found on pages 96-111.

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 middle 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.

Work Sample & Commentary: *Light Reflection*

The task

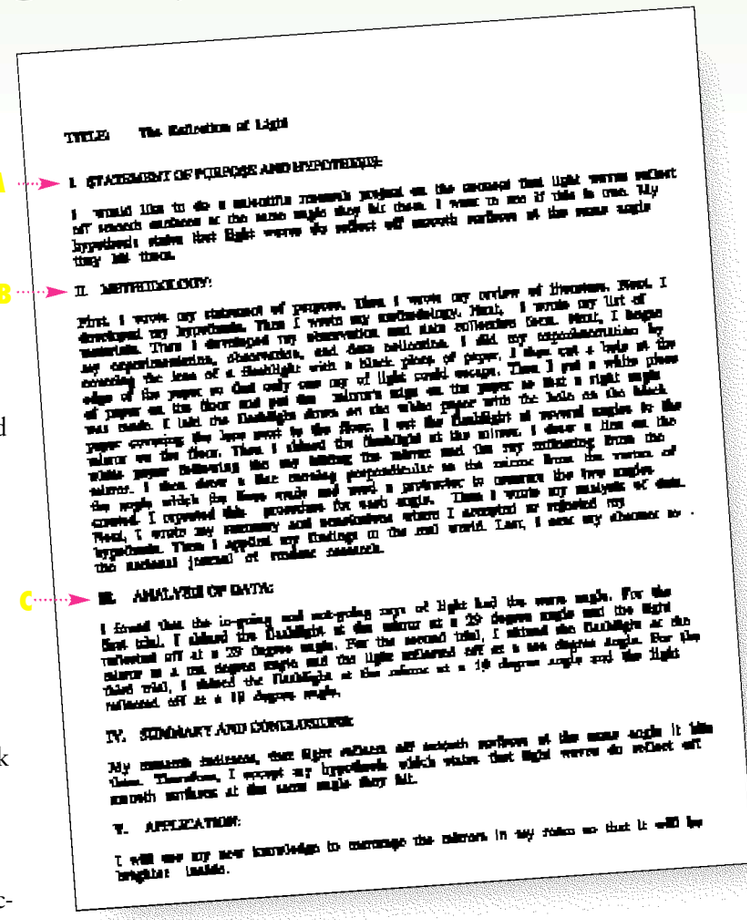
The National Student Research Center encourages the establishment of student research centers in schools throughout the United States and around the world. The Center facilitates the exchange of information by publishing a journal of student investigations and by use of the Internet (nsrcmms@aol.com). 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 a group
in class	as homework
with teacher feedback	with peer feedback
timed	opportunity for revision

Each student was allowed to select the topic for their study. This student chose to study the reflection of light on smooth surfaces. This investigation, therefore, adds to the components required for the format by providing evidence of an understanding of concepts in physical sciences.



TITLE: The Reflection of Light

A → I. STATEMENT OF PURPOSE AND HYPOTHESIS:

I would like to do a scientific research project on the concept that light waves reflect off smooth surfaces at the same angle they hit them. I want to see if this is true. My hypothesis states that light waves do reflect off smooth surfaces at the same angle they hit them.

B → II. METHODOLOGY:

First, I wrote my statement of purpose. Then I wrote my review of literature. Next, I developed my hypothesis. Then I wrote my methodology. Next, I wrote my list of materials. Then I developed my observation and data collection form. Next, I began my experimentation, observation, and data collection. I did my experimentation by covering the lens of a flashlight with a black piece of paper. I then cut a hole in the edge of the paper so that only one ray of light could escape. Then I put a white piece of paper on the floor and put the mirror upright on the paper so that a right angle was made. I hit the flashlight down on the white paper with the hole in the black paper covering the lens next to the floor. I set the flashlight at several angles to the mirror on the floor. Then I placed the flashlight at the mirror. I drew a line on the white paper following the ray hitting the mirror and the ray reflecting from the mirror. I then drew a line curving perpendicular to the mirror from the vertex of the angle which the lines made and used a protractor to measure the two angles created. I repeated this procedure for each angle. Then I wrote my analysis of data. Next, I wrote my summary and conclusions where I accepted or rejected my hypothesis. Then I applied my findings in the real world. Last, I sent my charmer to the national journal of student research.

C → III. ANALYSIS OF DATA:

I found that the in-going and out-going rays of light had the same angle. For the first trial, I placed the flashlight at the mirror at a 25 degree angle and the light reflected off at a 25 degree angle. For the second trial, I placed the flashlight at the mirror at a 55 degree angle and the light reflected off at a 55 degree angle. For the third trial, I placed the flashlight at the mirror at a 15 degree angle and the light reflected off at a 15 degree angle.

IV. SUMMARY AND CONCLUSION:

My research indicates that light reflects off smooth surfaces at the same angle it hits them. Therefore, I accept my hypothesis which states that light waves do reflect off smooth surfaces at the same angle they hit.

V. APPLICATION:

I will use my new knowledge to rearrange the mirrors in my house so that it will be brighter inside.

The Student Researcher. Used by permission of the National Student Research Center, Dr. John I. Swang, Mandeville Middle School, 2525 Soult Street, Mandeville, Louisiana 70448. 504-626-5980 or nsrcmms@aol.com.

What the work shows

S1 c Physical Sciences Concepts: The student produces evidence that demonstrates understanding of transfer of energy, such as transformation of energy as…light….

This work is limited to a single but important concept. It provides evidence for understanding that light is reflected off smooth surfaces, that there is regularity to that process, and that there is a way to state the relationship between the "in-going" and "out-going" angles quantitatively.

S5 a Scientific Thinking: The student frames questions to distinguish cause and effect; and identifies or controls variables in experimental and non-experimental research settings.

A The question is direct and clear.

B The procedure is well detailed; its repetition shows evidence of controlling variables.

S5 c Scientific Thinking: The student uses evidence from reliable sources to develop descriptions, explanations, and models.

First hand experimentation is a reliable source, providing the procedures are clear and variables are controlled.

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

- **S1 c Physical Sciences Concepts: Transfer of energy.**
- **S5 a Scientific Thinking: Frame questions and control variables.**
- **S5 c Scientific Thinking: Use evidence from reliable sources.**
- **S5 d Scientific Thinking: Distinguish between fact and opinion.**
- **S5 e Scientific Thinking: Evaluate accuracy, design, and outcomes.**
- **S5 f Scientific Thinking: Work in teams.**
- **S6 a Scientific Tools and Technologies: Use technology and tools to observe and measure.**

The quotations from the Science performance descriptions in this commentary are excerpted. The complete performance descriptions are shown on pages 92-95.

S6 makes explicit reference to using telecommunications to acquire and share information. A recent National Center on Education Statistics survey recently reported that only 50% of schools and fewer than 9% of instructional rooms currently have access to the Internet. We know 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. New Standards partners have made a commitment to create the learning environments where students can develop the knowledge and skills delineated here.

Physical Sciences Concepts S1
Life Sciences Concepts
Earth and Space Sciences Concepts
Scientific Connections and Applications
Scientific Thinking S5
Scientific Tools and Technologies S6
Scientific Communication
Scientific Investigation

Light Reflection

S5 d Scientific Thinking: The student proposes, recognizes, analyzes, considers, and critiques alternative explanations; and distinguishes between fact and opinion.

A There are many concepts in the physical sciences that students are expected to accept at face value. Many students find it necessary to experiment directly and to confirm for themselves things that are already "known." This experimentation is part of "distinguishes fact from opinion"; questioning "known facts" is an important part of Scientific Thinking at the middle school level.

S5 e Scientific Thinking: The student identifies problems; proposes and implements solutions; and evaluates the accuracy, design, and outcomes of investigations.

C

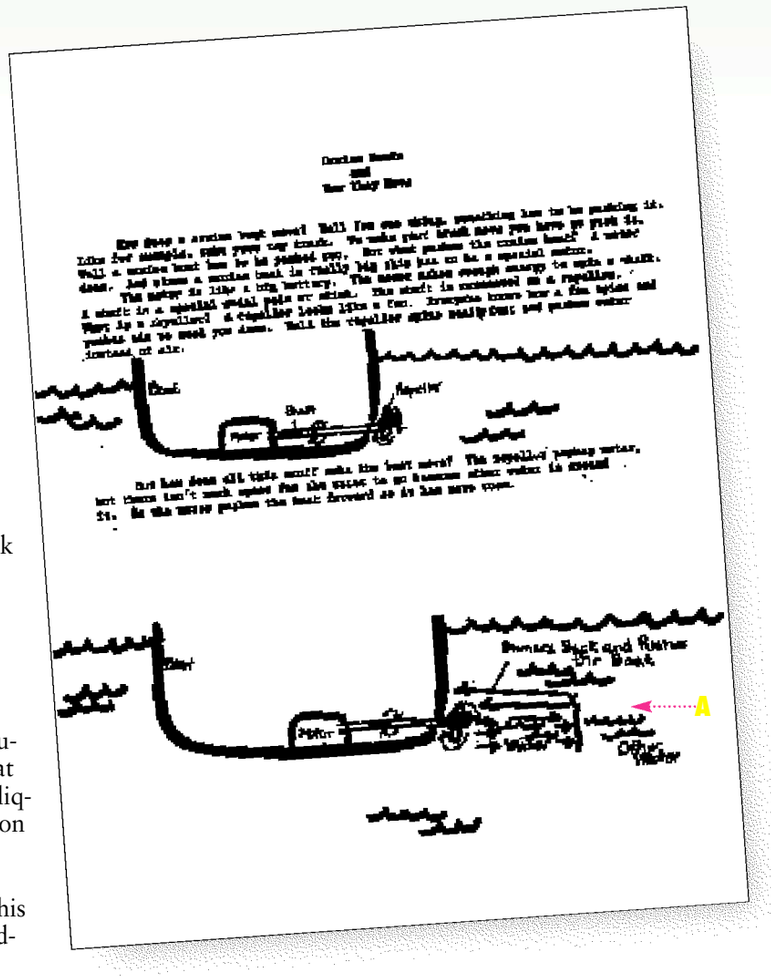
S5 f Scientific Thinking: The student works individually and in teams to collect and share information and ideas.

The format for work submitted to the National Student Research Center requires peer review to strengthen the work.

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

B The somewhat complex method for gathering data is well designed to yield accurate measurements. The precise manipulation of a light source, a mirror, and a protractor to obtain accurate data is standard-setting work at the middle school level.

Work Sample & Commentary: *Cruise Boats*



The task

After a unit of study on motions and forces, students were asked to explain how cruise boats worked. The explanation was supposed to be limited to two pages and written at a level that could be understood by a five to ten year-old child.

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

Science required by the task

The context of a liquid medium may have been confusing to the student. For a middle school student, it is somewhat advanced to understand that the same laws of motion apply to both gas and liquid environments (with forces modified by friction and resistance), when the student has probably learned about forces only in air. The student is asked only to tell what makes the boat move. This constraint makes the task manageable at the middle school level.

The quotations from the Science performance descriptions in this commentary are excerpted. The complete performance descriptions are shown on pages 92-95.

Physical Sciences Concepts S1
Life Sciences Concepts
Earth and Space Sciences Concepts
Scientific Connections and Applications S4
Scientific Thinking
Scientific Tools and Technologies
Scientific Communication S7
Scientific Investigation

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

- **S1 b Physical Sciences Concepts: Motions and forces.**
- **S4 a Scientific Connections and Applications: Big ideas and unifying concepts.**
- **S7 a Scientific Communication: Represent data in multiple ways.**
- **S7 e Scientific Communication: Communicate in a form suited to the purpose and the audience.**

What the work shows

S1 b Physical Sciences Concepts: The student produces evidence that demonstrates understanding of motions and forces, such as inertia and the net effects of balanced and unbalanced forces.

The relationship between force and motion is easier to illustrate in a familiar environment. The student had to apply the concept in an unfamiliar setting in order to explain the forces in a liquid medium.

A This shows an accurate explanation of motions and forces by explaining that a force in one direction always results in a force in the opposite direction.

B Here is a correct explanation of the forces operating in this system. The student stated that the faster the movement of the water the faster the forward movement of the boat.

Cruise Boats

S4 a Scientific Connections and Applications: The student produces evidence that demonstrates understanding of big ideas and unifying concepts, such as…cause and effect.

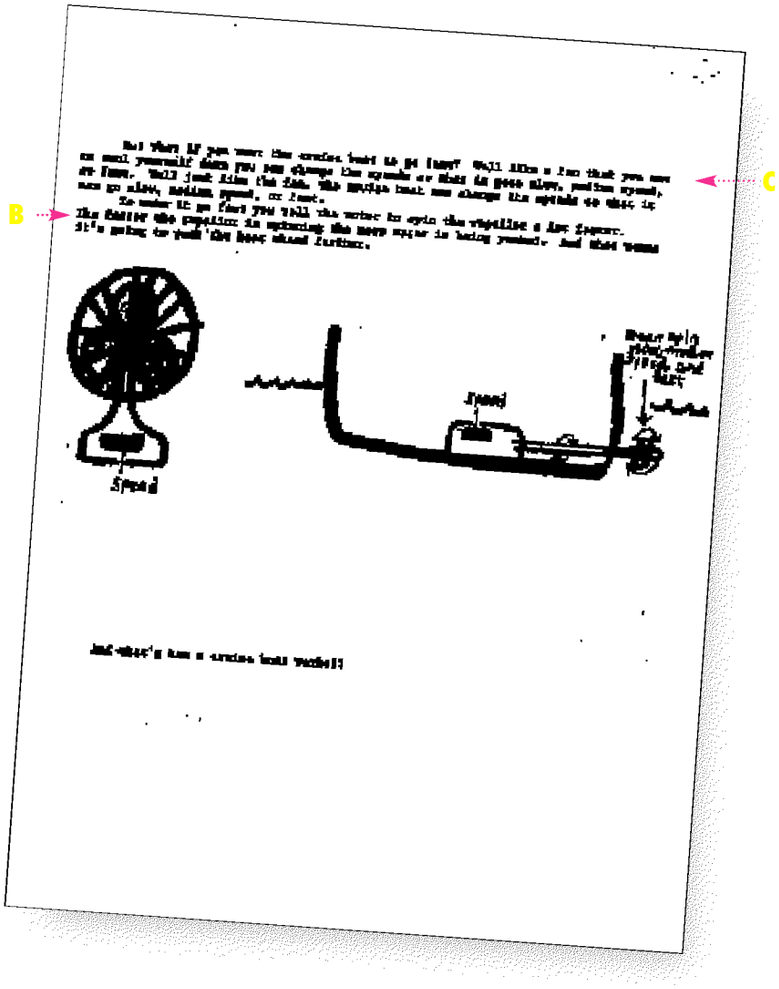
C The use of the fan to explain how ships might move faster is evidence for an understanding of the link between the shape of the fan and the behavior of a similar design in a different setting (water). The idea of cause and effect is illustrated in the explanation that, as the fans move faster, more water is pushed, causing greater forward motion.

S7 a Scientific Communication: The student represents data and results in multiple ways, such as…drawings, diagrams, and artwork; and technical and creative writing.

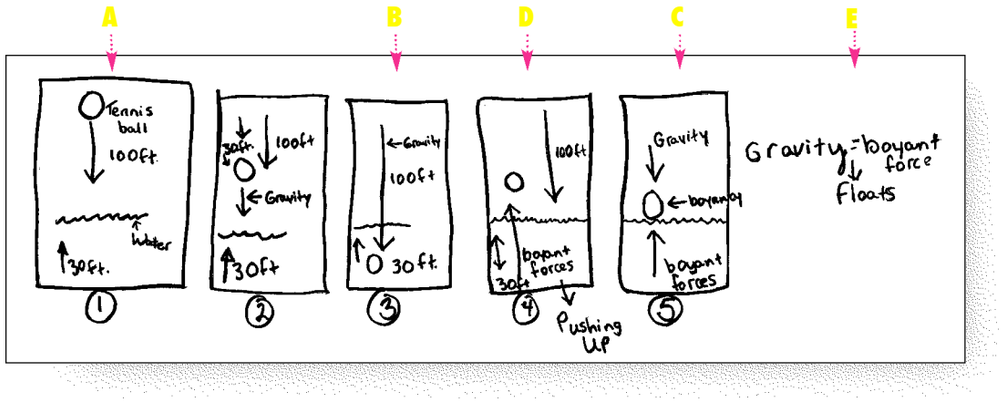
The use of drawings to accompany the written explanation is an effective way to illustrate the forces operating in this system.

S7 e Scientific Communication: The student communicates in a form suited to the purpose and the audience….

The task asked for an explanation to a specific audience (five- to ten-year-olds). This is an appropriate level of detail for a complete explanation to a younger student.



Work Sample & Commentary: *Buoyancy*



The quotations from the Science performance descriptions in this commentary are excerpted. The complete performance descriptions are shown on pages 92-95.

The task

Students who had been studying buoyant forces with vessels were asked to show what would happen to a tennis ball dropped from a height of 100 feet into 30 feet of water.

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 followed a unit of study on vessels in which forces and motions were studied in detail. Without this extended instruction, such a task would not ordinarily evoke a response such as this from a middle school student.

What the work shows

S1 b Physical Sciences Concepts: The student produces evidence that demonstrates understanding of motions and forces, such as…net effects of balanced and unbalanced forces.

The storyboard shows an analysis of the movement of the falling ball, seemingly a single action. The forces acting upon this moving object, however, are constantly changing, as represented by the changing lengths of the arrows.

A B The arrow lengths depict the forces acting upon the ball as unbalanced. The ball is either beneath the water or above the water.

C The arrows for gravity and buoyant forces are of equal length. The ball is depicted as floating, demonstrating that when the force of gravity is equal to the force of buoyancy, an object will float.

Note that the length of the arrows depicting the force of gravity should be constant across all frames, so there may be confusion between gravity and velocity.

D While the arrow depicting buoyancy appears to be acting outside the water in this frame, this misconception is not unusual for a middle school student.

E The evidence for conceptual understanding of balanced forces in the final frame is confirmed by the statement: "Gravity = buoyant force floats."

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

S1 b Physical Sciences Concepts: Motions and forces.

Work Sample & Commentary: *Discovering Density*

The task

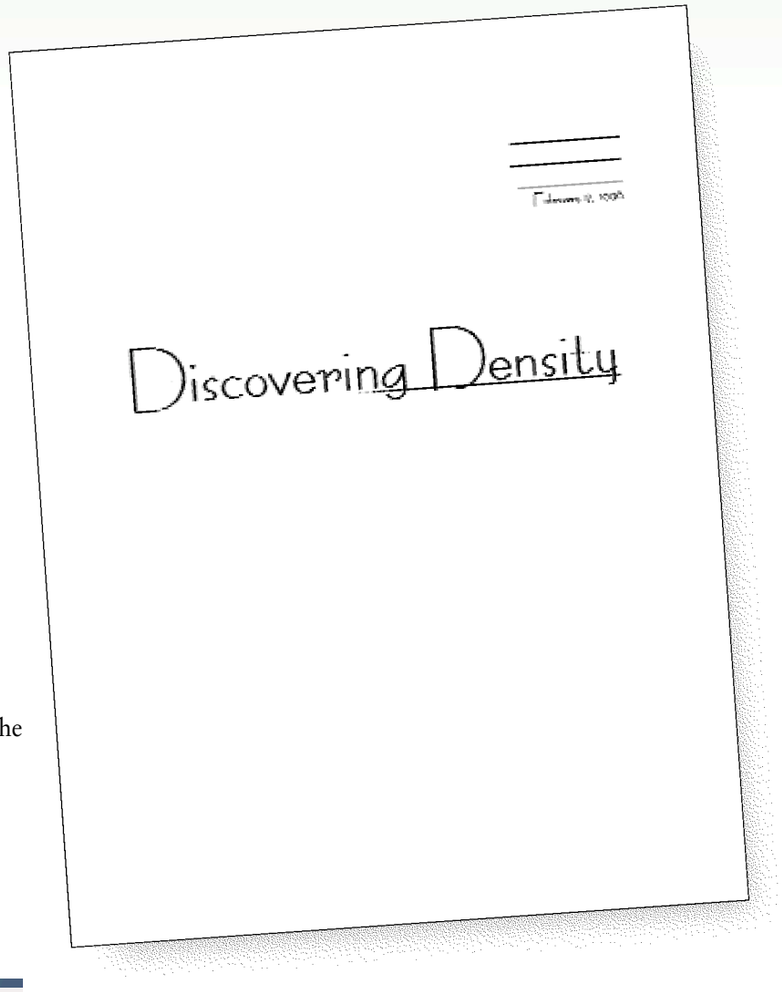
Following classroom discussion about the concept of density, students performed an extensive laboratory investigation. In the lab write up the students were asked to:

- discuss the definition of density;
- state a clear purpose for the investigation;
- give four clearly stated hypotheses;
- list all materials;
- clearly organize and label data;
- discuss any observed patterns;
- clearly explain laboratory procedures;
- summarize results;
- suggest ideas for future study.

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


Discovering Density

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

- **S1 a Physical Sciences Concepts: Properties and changes of properties in matter.**
- **S4 a Scientific Connections and Applications: Big ideas and unifying concepts.**
- **S5 b Scientific Thinking: Use concepts from Science Standards 1 to 4 to explain observations and phenomena.**
- **S5 c Scientific Thinking: Use evidence from reliable sources.**
- **S5 e Scientific Thinking: Evaluate the accuracy, design, and outcomes of investigations.**
- **S5 f Scientific Thinking: Work individually and in teams.**
- **S6 a Scientific Tools and Technologies: Use technology and tools to observe and measure.**
- **S7 a Scientific Communication: Represent data and results in multiple ways.**
- **S7 e Scientific Communication: Communicate in a form suited to the purpose and the audience.**

What the work shows

S1 a Physical Sciences Concepts: The student produces evidence that demonstrates understanding of properties and changes of properties in matter, such as density....

A B There is clear evidence here and throughout the work that the student understands how volume and mass relate to density.

C There is a misconception stated here about air having zero mass.

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

D E There are a number of places in this work where the student acknowledged that volume can remain constant and yet, if mass increases or decreases, the density is changed.

F The student provided evidence of understanding that if the density of an object is less than 1.0 g/ml the object will float in water.

The quotations from the Science performance descriptions in this commentary are excerpted. The complete performance descriptions are shown on pages 92-95.

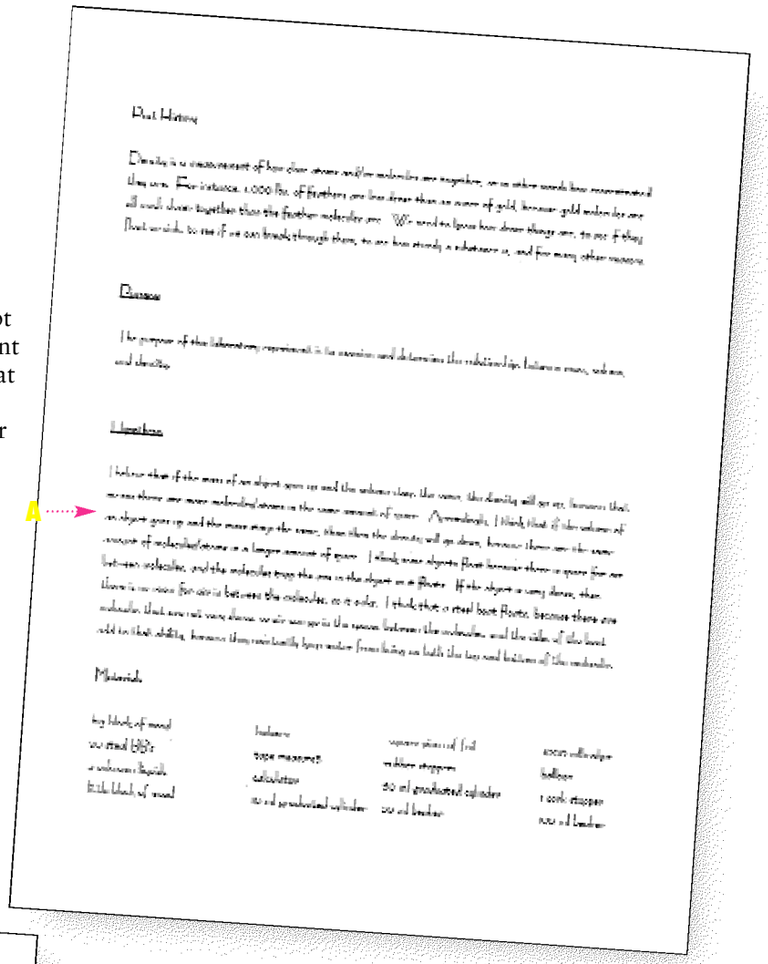
Discovering Density

S5 b Scientific Thinking: The student uses concepts from Science Standards 1 to 4 to explain a variety of observations and phenomena.

E The conclusion ties together the concept of density and why objects in the experiment floated and why some sank. This shows that the student was able to use her conceptual understanding of density to predict whether an object would float or sink given information about the density of the medium into which the object is placed and the density of the object.

S5 c Scientific Thinking: The student uses evidence from reliable sources to develop descriptions, explanations, and models.

Throughout the work the student used information from reliable sources. One source was direct experimentation. However, the student took information, whether from the teacher or some other source, and explained some sophisticated concepts in her own voice.


Prior History

Density is a measurement of how close atoms and/or molecules are together, or in other words how compressed they are. For instance, 1,000 lbs. of feathers are less dense than an ounce of gold, because gold molecules are all much closer together than the feather molecules are. We used an iceberg, how does things sink, to see if they float we wish to see if we can break through them, we use bow strength, a substance is, and for many other reasons.

Purpose

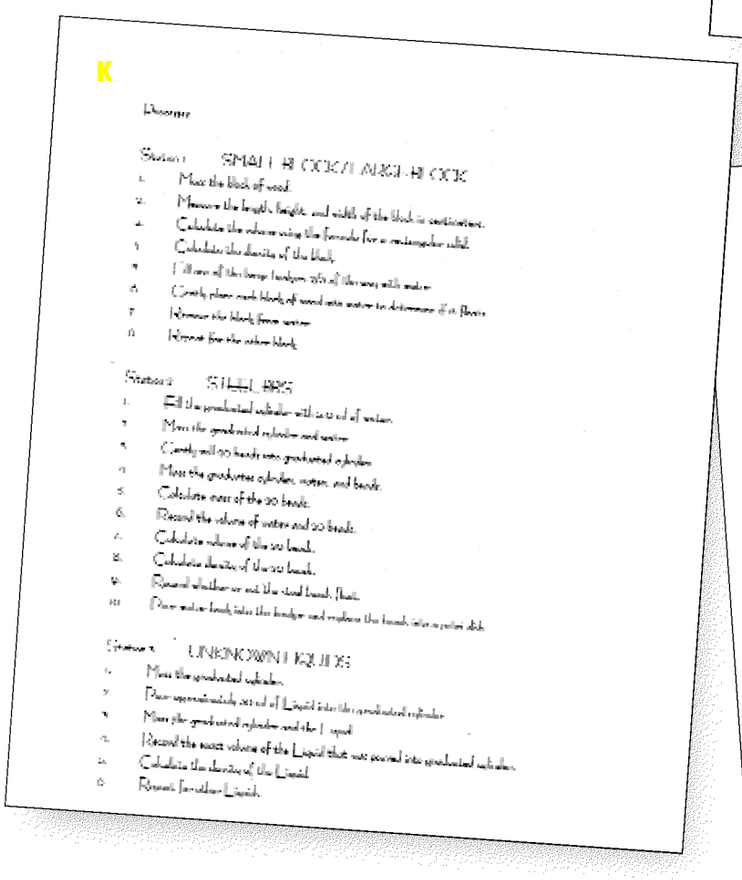
The purpose of this laboratory experiment is to examine and determine the relationship between mass, volume, and density.

Hypothesis

I believe that if the mass of an object goes up and the volume stays the same, the density will go up, because that means there are more molecules/atoms in the same amount of space. Correspondingly, I think that if the volume of an object goes up and the mass stays the same, then then the density will go down, because there are the same amount of molecules/atoms in a larger amount of space. I think some objects float because there is space for air between molecules, and the molecules trapp the air in the object so it floats. If the object is very dense, then there is no room for air in between the molecules, so it sinks. I think that a steel boat floats, because there are molecules that are not very dense, so air can go in the spaces between the molecules, and the sides of the boat add to their ability, because they can hardly keep water from being on both the top and bottom of the molecules.

Materials

big block of wood	balance	square piece of foil	aqua colored balloon
20 steel BBs	tape measure	rubber stopper	balloon
2 unknown liquids	calculator	50 ml graduated cylinder	1 cork stopper
little block of wood	10 ml graduated cylinder	20 ml beaker	100 ml beaker


K

Procedure

Station 1 SMALL BLOCK/LARGE BLOCK

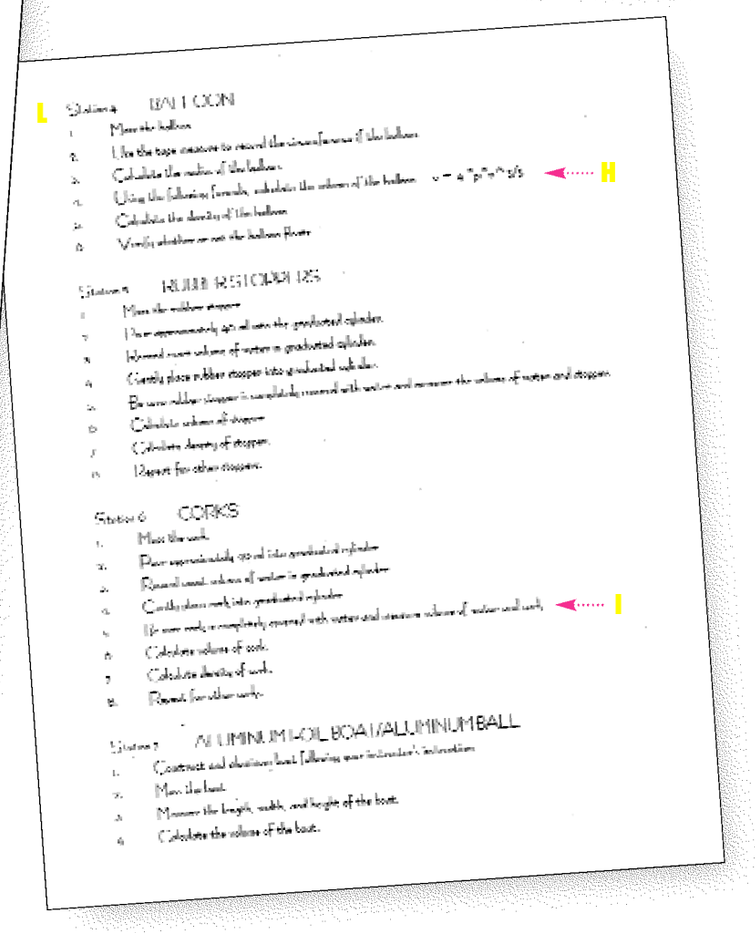
1. Place the block of wood.
2. Measure the length, height, and width of the block in centimeters.
3. Calculate the volume using the formula for a rectangular solid.
4. Calculate the density of the block.
5. Fill one of the large beakers 75% of the way with water.
6. Gently place each block of wood into water to determine if it floats.
7. Remove the block from water.
8. Repeat for the other block.

Station 2 STEEL BBS

1. Fill the graduated cylinder with 10 ml of water.
2. Place the graduated cylinder and water.
3. Gently roll 20 beads into graduated cylinder.
4. Place the graduated cylinder, water, and beads.
5. Calculate mass of the 20 beads.
6. Record the volume of water and 20 beads.
7. Calculate volume of the 20 beads.
8. Calculate density of the 20 beads.
9. Record whether or not the steel beads float.
10. Place water beads into the beaker and replace the beads into water dish.

Station 3 UNKNOWN LIQUIDS

1. Place the graduated cylinder.
2. Place approximately 10 ml of Liquid 1 into the graduated cylinder.
3. Place the graduated cylinder and the Liquid.
4. Record the exact volume of the Liquid that was poured into graduated cylinder.
5. Calculate the density of the Liquid.
6. Repeat for other Liquid.


L

Station 4 BALLOON

1. Place the balloon.
2. Use the tape measure to record the circumference of the balloon.
3. Calculate the radius of the balloon.
4. Using the following formula, calculate the volume of the balloon. $v = 4/3 * pi * r^3$
5. Calculate the density of the balloon.
6. Verify whether or not the balloon floats.

Station 5 RUBBER STOPPERS

1. Place the rubber stopper.
2. Place approximately 40 ml into the graduated cylinder.
3. Record exact volume of water in graduated cylinder.
4. Gently place rubber stopper into graduated cylinder.
5. Be sure rubber stopper is completely covered with water and measure the volume of water and stopper.
6. Calculate volume of stopper.
7. Calculate density of stopper.
8. Repeat for other stoppers.

Station 6 CORKS

1. Place the cork.
2. Place approximately 40 ml into graduated cylinder.
3. Record exact volume of water in graduated cylinder.
4. Gently place cork into graduated cylinder.
5. Be sure cork is completely covered with water and measure volume of water and cork.
6. Calculate volume of cork.
7. Calculate density of cork.
8. Repeat for other corks.

Station 7 ALUMINUM FOIL BOAT/ALUMINUM BALL

1. Construct and aluminum boat following your instructor's instructions.
2. Place the boat.
3. Measure the length, width, and height of the boat.
4. Calculate the volume of the boat.

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

Discovering Density

S5 e Scientific Thinking: The student evaluates the accuracy, design, and outcomes of investigations.

G The student identified several reasonable sources of measurement error.

S5 f Scientific Thinking: The student works individually and in teams to collect and share information and ideas.

S6 a Scientific Tools and Technologies: The student uses technology and tools (such as traditional laboratory equipment…) to…measure objects…indirectly….

H The student determined the volume of the balloon by using the formula for a sphere.

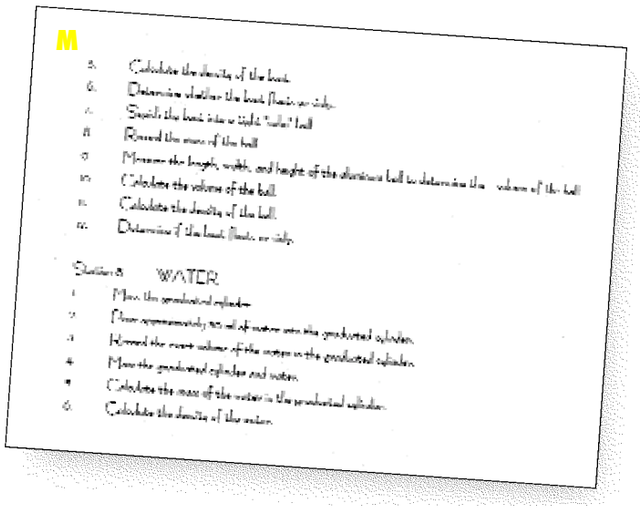
I The student determined the volume of an irregularly shaped object by using water displacement.

S7 a Scientific Communication: The student represents data and results in multiple ways, such as numbers, tables, and technical…writing.

J The student presented data in tabular form and analyzed the data in writing.

S7 e Scientific Communication: The student communicates in a form suited to the purpose and the audience, such as by writing instructions that others can follow….

K L M

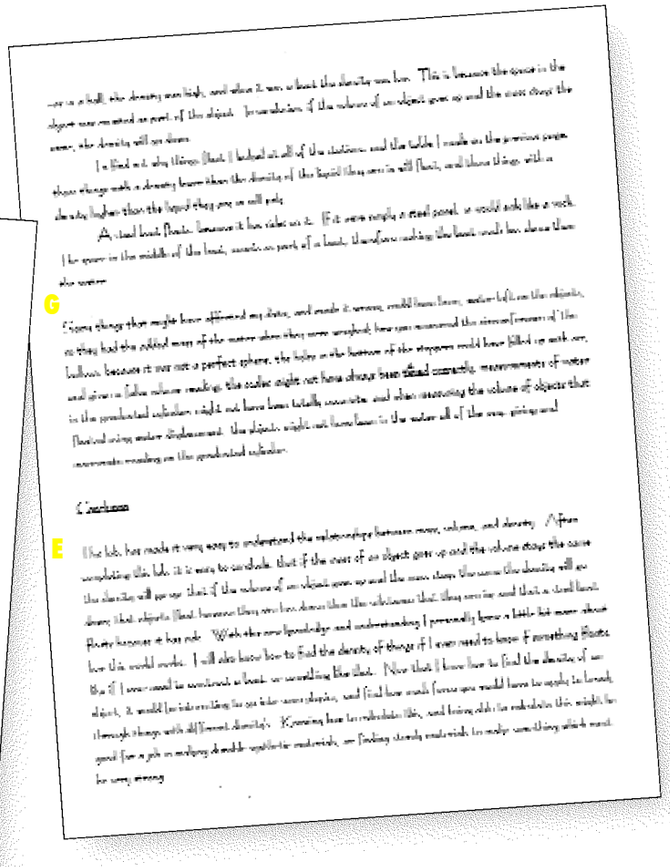


M

3. Calculate the density of the boat.
4. Determine whether the boat floats or sinks.
5. Sink the boat into a tight "ball" ball
6. Record the mass of the ball
7. Measure the length, width, and height of the aluminum ball to determine the volume of the ball
8. Calculate the volume of the ball.
9. Calculate the density of the ball.
10. Determine if the boat floats or sinks.

Station 3 WATER

1. Move the graduated cylinder
2. Move approximately 100 ml of water into the graduated cylinder.
3. Record the exact volume of the water in the graduated cylinder.
4. Move the graduated cylinder and water.
5. Calculate the mass of the water in the graduated cylinder.
6. Calculate the density of the water.



B

The density of an object is most dependent on mass. There are some other factors concerning mass that contribute to the density of an object. At the atomic level each individual atom/molecule would weight a lot, thus affecting the mass which affects the density. In theory could be a number of atoms/molecules squished up in a small space, which affects the mass and therefore affecting the volume. This is represented by all of the stations in the laboratory. In all of the stations, the mass and volume were taken, and in each case the individual weight of each atom/molecule and the weight of how many atoms/molecules there were affected the mass.

F Water's density is approximately 1.0 g/ml. You can see this on the Station 3 table of my data. With the data of all of the things that we testing whether they floated or sank, we can be determined that things that float, have a density of less than 1.0 g/ml, and all of the things that sink have a density of greater than 1.0.

Floats	Density	Sinks	Density
Small Block	0.898 g/ml	Steel Beads	7 g/ml
Large Block	0.616 g/ml	Sm. Stopper	1.1 g/ml
Bottom	0.0052 g/ml	Med. Stopper	1.3 g/ml
Small Cork	0.15 g/ml	Lg. Stopper	1.3 g/ml
Medium Cork	0.2 g/ml	Alum. Ball	1.2 g/ml
Large Cork	0.17 g/ml		
Alum. Boat	0.037 g/ml		

J

C The aluminum boat floated, because its density was above 1.0 g/ml. Most of the masses, is because the weight source is the middle of the boat (which weighs nothing) is wasted in the volume, thus when you divide mass by volume the number drops greatly. With the ball you measured what if atoms/molecules were a small space, and the volume was so very small, when you divide the number shooted above 1.0 g/ml and it sinks.

D To find what happens to the density of an object the mass of an object goes up, and the volume stays the same I looked at stations 2 and 3, and 4. If you look at the stoppers and only look at the same volume, you will see that the mass of the stopper is larger. The density of the same measure object is higher in all three (small, medium, and largest) cases. In the liquids stations the volume always stayed the same, yet the mass increase but still always had a high density. So it can be concluded that if the mass of an object goes up and the volume stays the same, the density will go up.

To find what happens to the density of an object if the volume goes up and the mass stays the same I looked at stations 1 and 2 and 3. (If we had a aluminum ball (sink), then both it into a boat). When the aluminum

up in a ball, the density was high, and when it was in boat the density was low. This is because the space in the object was included as part of the object. Increasing of the volume of an object goes up and the mass stays the same, the density will go down.

I found out why things float. I looked at all of the stations, and the table I made on the previous page. Those things with a density lower than the density of the liquid they are in will float, and those things with a density higher than the liquid they are in will sink.

A steel boat floats because it has sides on it. If it were simply a steel panel, it would sink like a rock. The space in the middle of the boat, counts as part of a boat, therefore making the boat could lay above than the water.

G Some things that might have affected my data, and made it wrong, could have been water left on the objects, as they had the added mass of the water when they were weighed. Here you measured the dimensions of the balloon because it was not a perfect sphere, the holes in the bottom of the stoppers could have filled up with air, and given a false volume reading, the scales might not have always been filled correctly, measurements of water in the graduated cylinder might not have been totally accurate, and when measuring the volume of objects that floated using water displacement, the objects might not have been in the water all of the way, giving and inaccurate reading on the graduated cylinder.

Conclusion

E The lab has made it very easy to understand the relationships between mass, volume, and density. After completing this lab, it is easy to conclude, that if the mass of an object goes up and the volume stays the same the density will go up, that if the volume of an object goes up and the mass stays the same the density will go down, that objects float, because they are less dense than the substance that they are in, and that a steel boat floats because it has sides. With the new knowledge and understanding I personally have a little bit more about how this world works. I will also know how to find the density of things if I ever need to know if something floats, or if I ever need to construct a boat, or something like that. Now that I know how to find the density of an object, it would be interesting for me to take some objects, and find how much force you would have to apply to break through things with different density's. Knowing how to calculate this, and being able to calculate this might be good for a job in studying double applicator materials, or finding steady materials to make something which must be very strong.

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

Work Sample & Commentary: *Seeds*

The task

Students participated in a garden project as part of a community summer program. During the project they were given casual instruction on plants, seeds, and weeds. To identify weeds, the students walked through a vacant lot near the garden wearing socks over their shoes. They collected and analyzed the seeds from their socks. They then sorted the seeds according to their own classification scheme.

One student took the investigation a further step and compared the oil (fat) content of different dicots.

Circumstances of performance

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

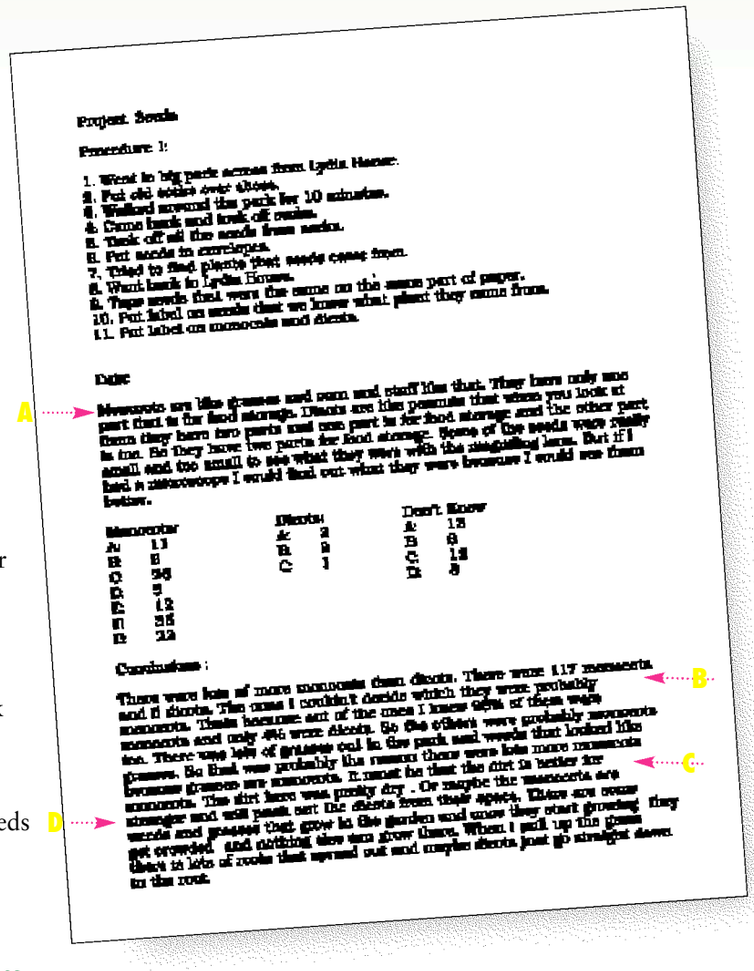
alone	in a group
in class	as homework
with teacher feedback	with peer feedback
timed	opportunity for revision

The fieldwork of gathering and classifying the seeds was done in a small group. The data analysis in both procedures was completed individually.

What the work shows

S2 a Life Sciences Concepts: The student produces evidence that demonstrates understanding of structure and function in living systems, such as the complementary nature of structure and function….

A The classification based on a functional characteristic of seeds shows evidence of an understanding of structure and function.



Project Seeds

Procedure 1:

1. Went to big park across from Lydia House.
2. Put old socks over shoes.
3. Walked around the park for 10 minutes.
4. Came back and took off socks.
5. Took off all the seeds from socks.
6. Put seeds in envelopes.
7. Tried to find plants that seeds came from.
8. Went back to Lydia House.
9. Taped seeds that were the same on the same part of paper.
10. Put label on seeds that we knew what plant they came from.
11. Put label on monocots and dicots.

Data

Monocots are like grasses and corn and stuff like that. They have only one part that is for food storage. Dicots are like peanuts that when you look at them they have two parts and one part is for food storage and the other part is too. So they have two parts for food storage. Some of the seeds were really small and too small to see what they were with the magnifying lens. But if I had a microscope I would find out what they were because I could see them better.

Monocots		Dicots		Don't Know	
A	11	A	2	A	13
B	8	B	9	B	8
C	36	C	1	C	12
D	5			D	8
E	12				
F	35				
G	22				

Conclusions:

There were lots of more monocots than dicots. There were 117 monocots and 11 dicots. The ones I couldn't decide which they were probably monocots. Thats because out of the ones I knew 98% of them were monocots and only 4% were dicots. So the others were probably monocots too. There was lots of grasses out in the park and weeds that looked like grasses. So that was probably the reason there were lots more monocots because grasses are monocots. It must be that the dirt is better for monocots. The dirt here was pretty dry . Or maybe the monocots are stronger and will push out the dicots from their space. There are some weeds and grasses that grow in the garden and once they start growing they get crowded and nothing else can grow there. When I pull up the grass there is lots of roots that spread out and maybe dicots just go straight down to the root.

S2 d Life Sciences Concepts: The student produces evidence that demonstrates understanding of populations and ecosystems, such as…the effects of resources and energy transfer on populations.

B The student identified the dominant group of plants in this particular population.

C The student identified a possible reason related to resources for the dominance of one species.

The quotations from the Science performance descriptions in this commentary are excerpted. The complete performance descriptions are shown on pages 92-95.

Best practice in science has always included intensive inquiry and investigation. There are many opportunities to learn science outside of school, including the Girl Scouts of the U.S.A., Boy Scouts of America, Boys and Girls Clubs of America, 4-H, and Future Farmers of America. The work done in these venues can and should be used to provide evidence of meeting these standards.

Physical Sciences Concepts
Life Sciences Concepts ◀ S2
Earth and Space Sciences Concepts
Scientific Connections and Applications
Scientific Thinking ◀ S5
Scientific Tools and Technologies
Scientific Communication
Scientific Investigation

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

- **S2 a Life Sciences Concepts: Structure and function.**
- **S2 d Life Sciences Concepts: Populations and ecosystems.**
- **S2 e Life Sciences Concepts: Adaptation of organisms.**
- **S5 a Scientific Thinking: Control variables.**
- **S5 b Scientific Thinking: Use concepts from Science Standards 1 to 4 to explain observations and phenomena.**
- **S5 d Scientific Thinking: Distinguish between fact and opinion.**
- **S5 e Scientific Thinking: Evaluate the accuracy, design, and outcomes of investigations.**

Seeds

S2 e Life Sciences Concepts: The student produces evidence that demonstrates understanding of…adaptation of organisms….

D The student offered several possible adaptations to explain the population difference.

S5 a Scientific Thinking: The student…controls variables in experimental and non-experimental research settings.

E The student critiqued his own procedure by identifying variables which might have been controlled.

S5 b Scientific Thinking: The student uses concepts from Science Standards 1 to 4 to explain a variety of observations and phenomena.

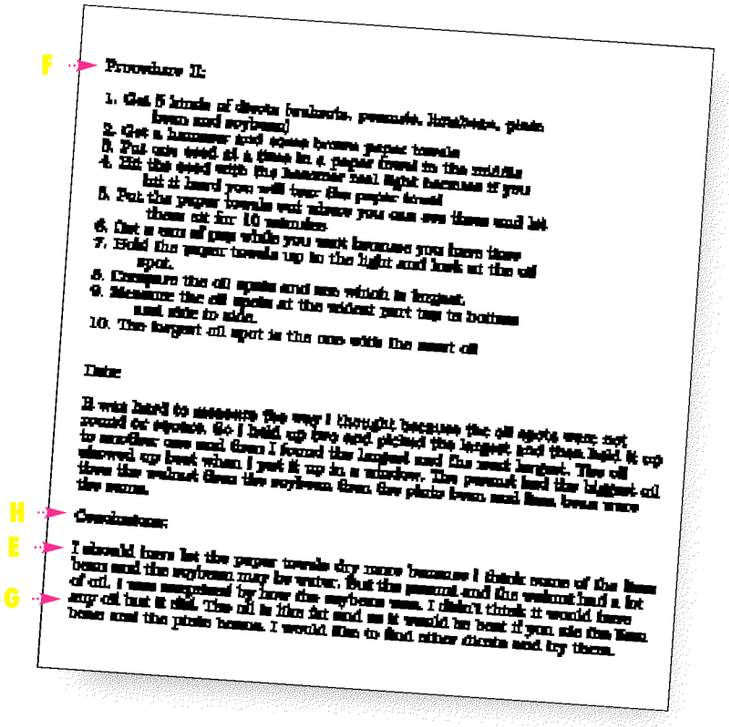
F The student used the understanding necessary to identify dicots in order to control the variable of seed type.

S5 d Scientific Thinking: The student…distinguishes between fact and opinion.

G The student based his conclusions on experimental data, not his opinion.

S5 e Scientific Thinking: The student…evaluates the accuracy, design, and outcomes of investigations.

H



F Procedure II:

1. Get 5 kinds of dicots (walnuts, peanuts, lentils, pinto bean and soybeans)
2. Get a hammer and some brown paper towels
3. Put one seed at a time in a paper towel in the middle
4. Hit the seed with the hammer real light because if you hit it hard you will tear the paper towel
5. Put the paper towels wet where you can see them and let them sit for 10 minutes
6. Get a can of pop while you wait because you have time
7. Hold the paper towels up to the light and look at the oil spot.
8. Compare the oil spots and see which is largest.
9. Measure the oil spots at the widest part top to bottom and side to side.
10. The largest oil spot is the one with the most oil

Date:

It was hard to measure the way I thought because the oil spots were not round or square. So I held up two and picked the largest and then held it up to another one and then I found the largest and the next largest. The oil showed up best when I put it up in a window. The peanut had the biggest oil then the walnut then the soybean then the pinto bean and then bean were the same.

H Conclusion:

E I should have let the paper towels dry more because I think some of the bean and the soybean may be water. But the peanut and the walnut had a lot of oil. I was surprised by how the soybean was. I didn't think it would have any oil but it did. The oil is like fat and so it would be best if you ate the bean bean and the pinto beans. I would like to find other dicots and try them.

G

Work Sample & Commentary: *Passive Solar Homes*

The task

Students were asked to design and build a model that would illustrate a form of renewable energy and to make a presentation. They needed to complete background research in order to come up with an accurate design.

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 student chose the topic of passive solar homes. Included here are the written report, a design drawing, and notes for the presentation. The model was built but is not included here.

What the work shows

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

Throughout the work, the student explained that solar energy is reliable and renewable, cost-efficient and less wasteful than conventional forms of home energy, and has minimum impact on the environment. For example solar energy is:

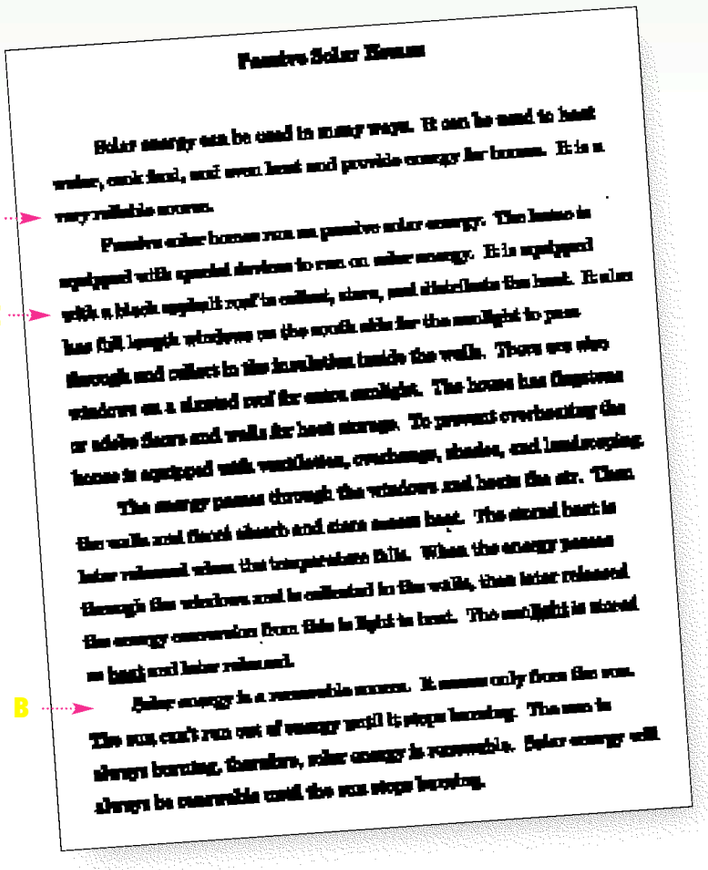
- **A** reliable;
- **B** renewable;
- **C** cost-efficient and less wasteful than conventional forms of home energy; and has
- **D** minimum impact on the environment.

The quotations from the Science performance descriptions in this commentary are excerpted. The complete performance descriptions are shown on pages 92-95.

Physical Sciences Concepts
Life Sciences Concepts
Earth and Space Sciences Concepts S3
Scientific Connections and Applications S4
Scientific Thinking
Scientific Tools and Technologies
Scientific Communication
Scientific Investigation

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

- **S3 d Earth and Space Sciences Concepts: Natural resource management.**
- **S4 a Scientific Connections and Applications: Big ideas and unifying concepts.**
- **S4 d Scientific Connections and Applications: Impact of technology.**



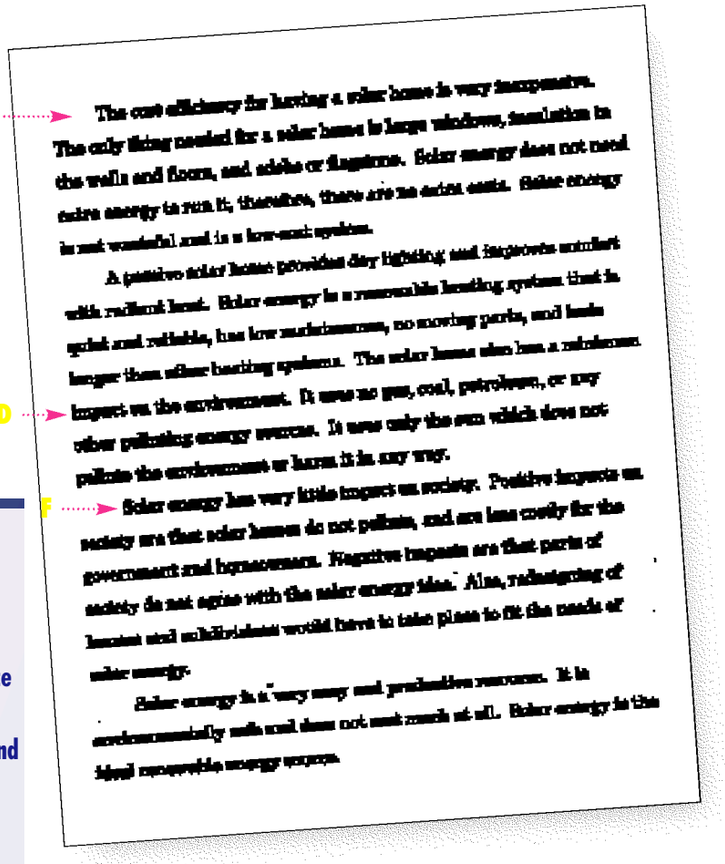
Passive Solar Homes

Solar energy can be used in many ways. It can be used to heat water, cook food, and even heat and provide energy for homes. It is a very reliable source. (A)

Passive solar homes run on passive solar energy. The house is equipped with special devices to run on solar energy. It is equipped with a black asphalt roof to collect, store, and distribute the heat. It also (E) has full length windows on the south side for the sunlight to pass through and collect in the insulation inside the walls. There are also windows on a slanted roof for extra sunlight. The house has fireplaces or adobe floors and walls for heat storage. To prevent overheating the house is equipped with ventilation, overhangs, shades, and landscaping.

The energy passes through the windows and heats the air. Then the walls and floors absorb and store season heat. The stored heat is later released when the temperature falls. When the energy passes through the windows and is collected in the walls, then later released the energy conversion from light to heat is heat. The sunlight is stored as heat and later released.

Solar energy is a renewable source. It comes only from the sun. (B) The sun can't run out of energy until it stops burning. The sun is always burning, therefore, solar energy is renewable. Solar energy will always be renewable until the sun stops burning.



The cost efficiency for having a solar home is very inexpensive. (C) The only thing needed for a solar home is large windows, insulation in the walls and floors, and adobe or fireplaces. Solar energy does not need extra energy to run it, therefore, there are no extra costs. Solar energy is not wasteful and is a low-cost system.

A passive solar home provides day lighting and improvers comfort with radiant heat. Solar energy is a renewable heating system that is quiet and reliable, has low maintenance, no moving parts, and lasts longer than other heating systems. The solar home also has a minimum impact on the environment. It uses no gas, coal, petroleum, or any (D) other polluting energy sources. It uses only the sun which does not pollute the environment or harm it in any way.

Solar energy has very little impact on society. Positive impacts on (F) society are that solar homes do not pollute, and are less costly for the government and homeowners. Negative impacts are that parts of society do not agree with the solar energy idea. Also, redesigning of houses and subdivisions would have to take place to fit the needs of solar energy.

Solar energy is a very easy and productive resource. It is environmentally safe and does not cost much at all. Solar energy is the ideal renewable energy source.

Passive Solar Homes

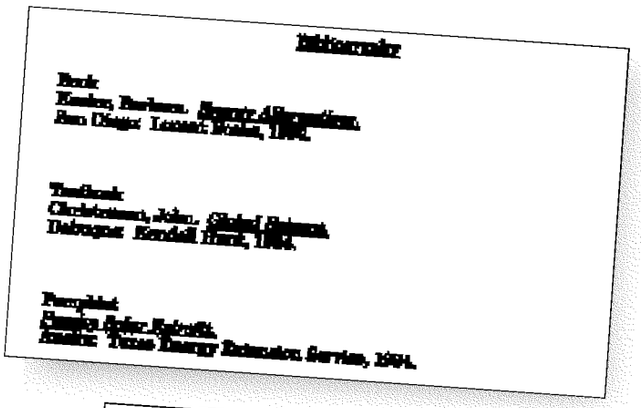
S4 a Scientific Connections and Applications: The student produces evidence that demonstrates understanding of big ideas and unifying concepts, such as…form and function….

E The student carefully explained the purpose for each of the components in a passive solar home.

S4 d Scientific Connections and Applications: The student produces evidence that demonstrates understanding of impact of technology, such as constraints and trade-offs….

F G The student analyzed the pros and cons of using solar energy. These concluding statements include consideration of some constraints and recognition of some trade-offs.

There are two constraints that are not mentioned: costs of technology and availability of sunshine. One could argue that the costs of technology would be underwritten and lowered if society as a whole had more enthusiasm for the concept. The availability of sunshine is less of a problem in the region where this student lives than in many other places in the United States.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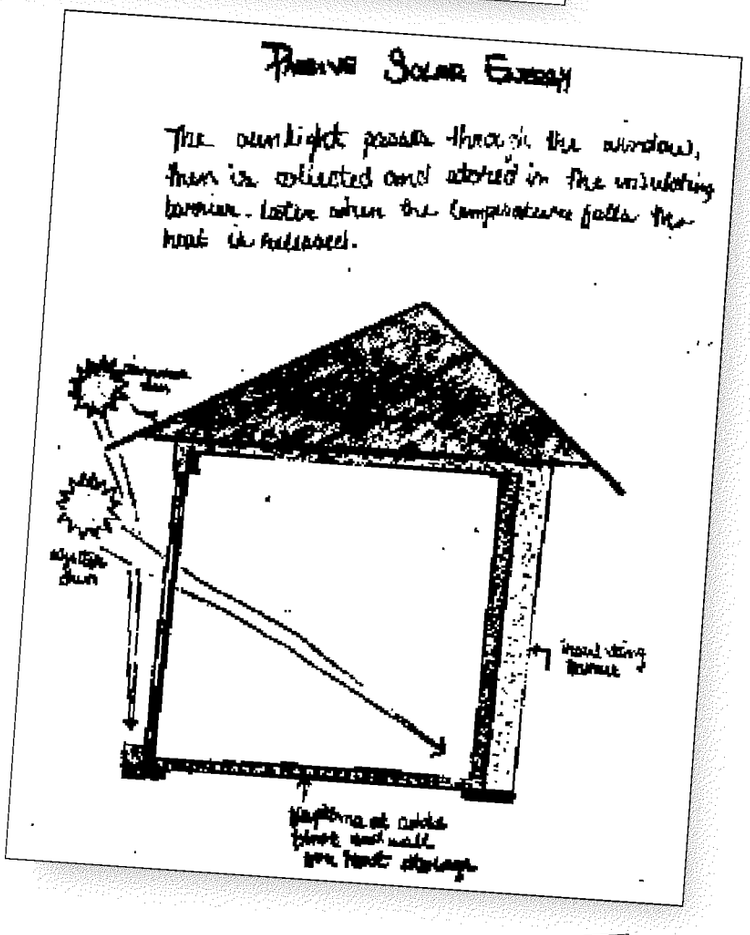
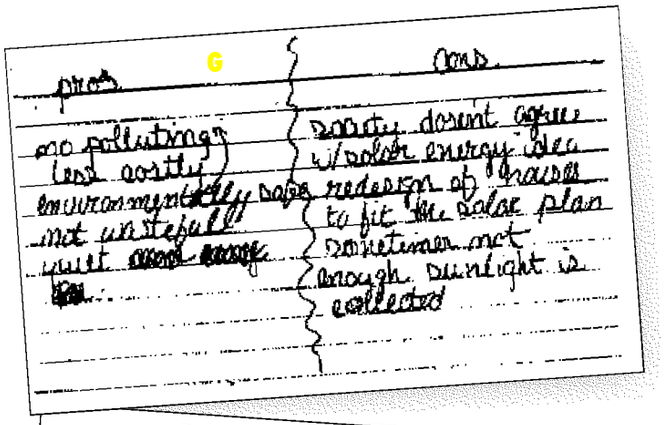
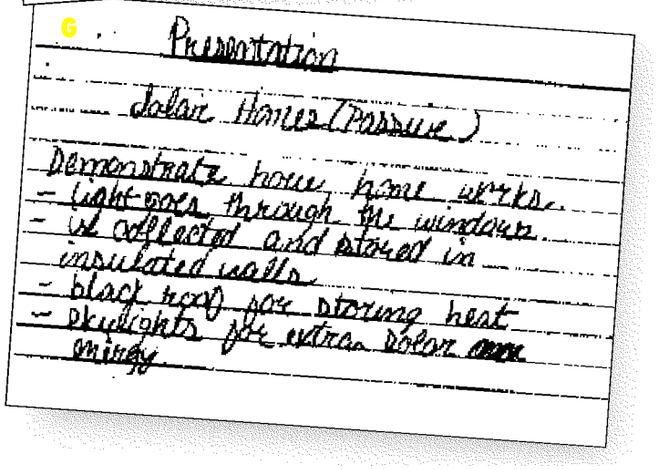


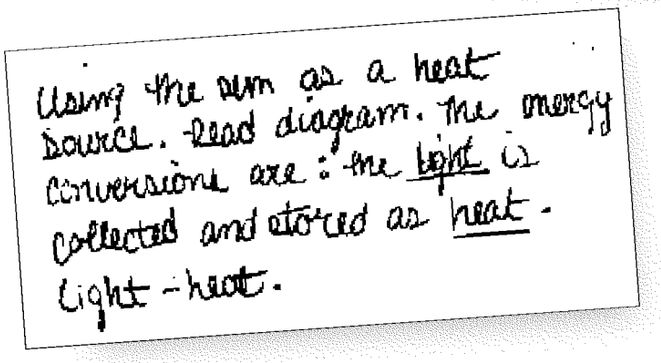

G

pros	cons
no pollution	society doesn't agree
less costly	w/solar energy idea
environmentally safe	redesign of houses
not wasteful	to fit the solar plan
quiet	sometimes not
	enough sunlight is
	collected


G Presentation

Solar Homes (Passive)

Demonstrate how home works.
- light goes through the windows.
- it collected and stored in insulated walls
- black roof for storing heat
- skylights for extra solar energy.


Using the sun as a heat source. Read diagram. The energy conversions are: the light is collected and stored as heat. Light - heat.

Work Sample & Commentary: *Moon Study*

The quotations from the Science performance descriptions in this commentary are excerpted. The complete performance descriptions are shown on pages 92-95.

The task

Students who had been studying the Solar System were asked to pursue an individual project relating to the Solar System. This student chose to learn more about the phases of the Moon, a concept he had recently studied but did not understand.

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

What the work shows

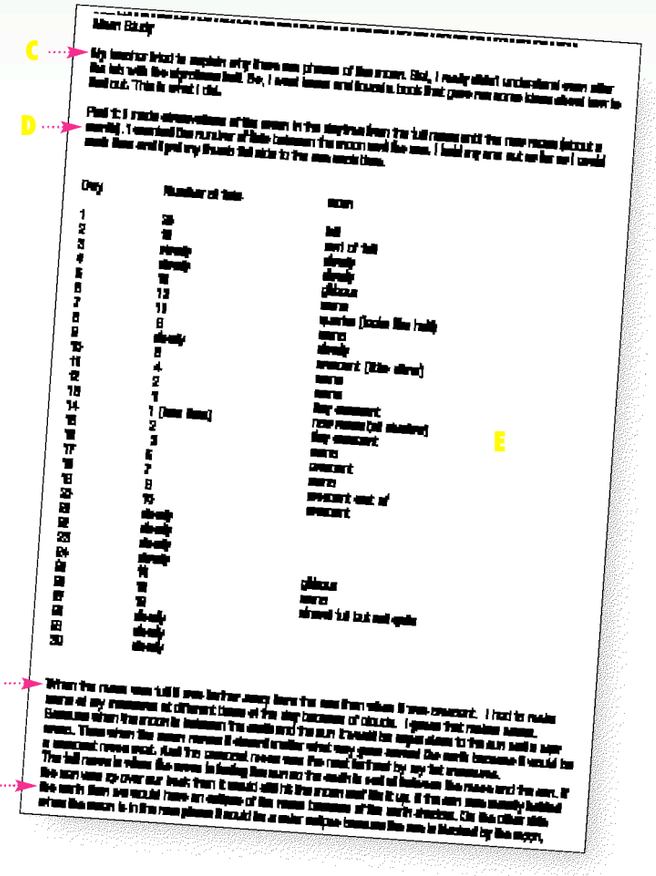
S3 c Earth and Space Sciences Concepts: The student produces evidence that demonstrates understanding of earth in the Solar System, such as the predictable motion of planets, moons, and other objects in the Solar System including days, years, moon phases, and eclipses....

A The student demonstrated knowledge of the relative position of the Sun and Moon.

A B The student gave an accurate explanation of solar and lunar eclipses based on his observations.

S5 c Scientific Thinking: The student uses evidence from reliable sources to develop descriptions, explanations, and models.

C The student did not understand what had happened in class, so he used a book and observation to construct his understanding.

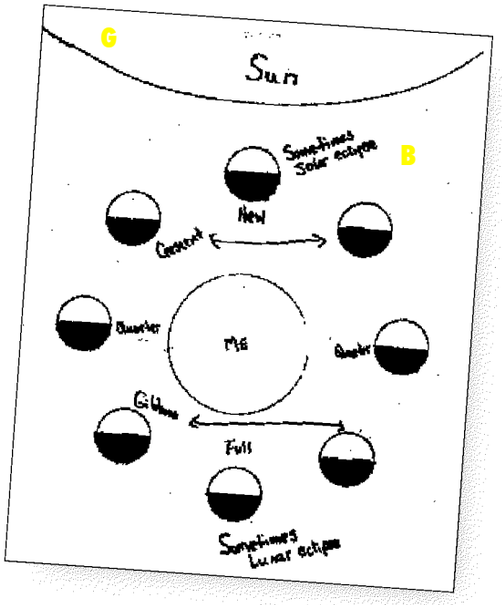


S6 a Scientific Tools and Technologies: The student uses technology and tools...to observe and measure objects...and phenomena,...remotely.

D The use of a fist as a measure is a traditional way to measure distance, but one that is an appropriate challenge to understand at the middle school level.

S7 a Scientific Communication: The student represents data and results in multiple ways, such as numbers, tables,...diagrams, and...writing.

E F G



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

- S3 c Earth and Space Sciences Concepts: Earth in the Solar System.
- S5 c Scientific Thinking: Use evidence from reliable sources.
- S6 a Scientific Tools and Technologies: Use technology and tools to observe and measure.
- S7 a Scientific Communication: Represent data and results in multiple ways.

Physical Sciences Concepts
Life Sciences Concepts
Earth and Space Sciences Concepts S3
Scientific Connections and Applications
Scientific Thinking S5
Scientific Tools and Technologies S6
Scientific Communication S7
Scientific Investigation

Work Sample & Commentary: *Spot Remover*

The task

In an on-demand task, students were asked to describe in detail an experiment that a person might perform to find out which of two spot removers is better for removing stains from fabrics.

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 was part of a state assessment and unrelated to the curriculum being studied.

What the work shows

S5 a Scientific Thinking: The student frames questions to distinguish cause and effect; and identifies or controls variables in experimental and non-experimental research settings.

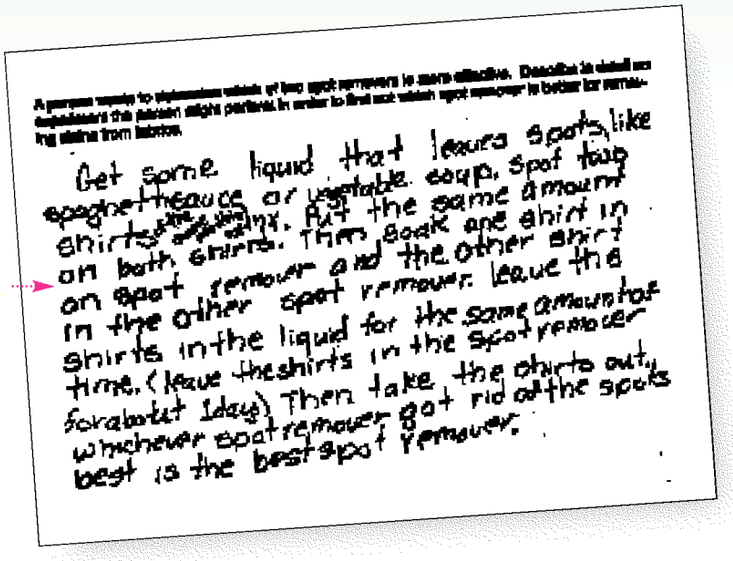
A In the first work sample, three variables are explicitly identified and controlled: "same material," "same amount on both shirts," and "same amount of time."

B In the second work sample, four variables are explicitly identified and controlled: "same material," "same amount of time [for staining]," and "same way," and "same amount of time [for washing]."

S7 d Scientific Communication: The student explains a scientific concept or procedure to other students.

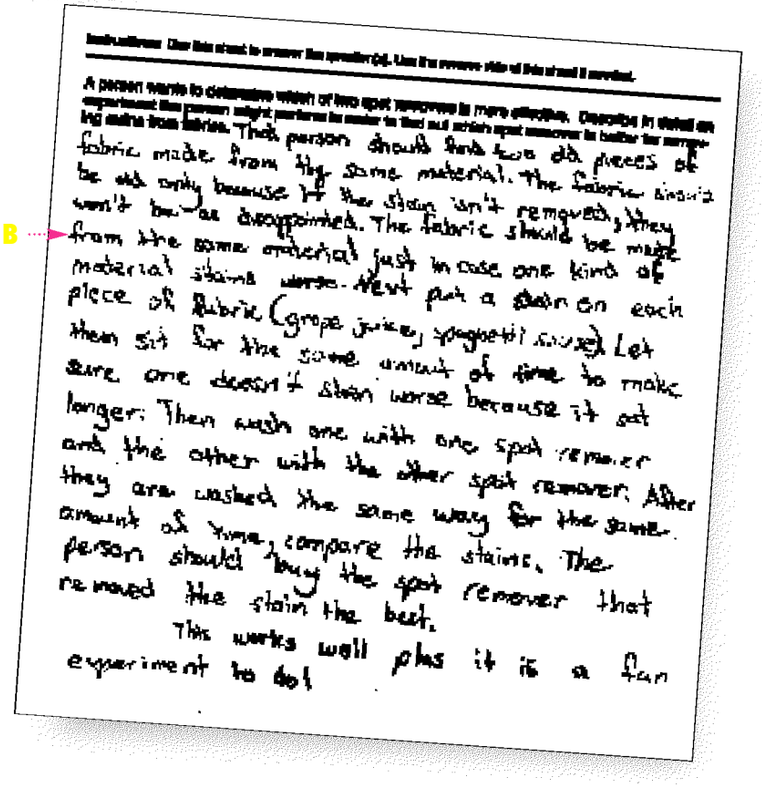
A B Both samples provide procedures that could be replicated by other students.

B Although not called for in the task, the second sample offers two explanations for the procedures, making the communication more effective.



A

Get some liquid that leaves spots, like spaghetti sauce or vegetable soup. Spot two shirts. Put the same amount on both shirts. Then soak one shirt in spot remover and the other shirt in the other spot remover. Leave the shirts in the liquid for the same amount of time. (Leave the shirts in the spot remover for about 1 day) Then take the shirts out, whichever spot remover got rid of the spots best is the best spot remover.



B

A person wants to determine which of two spot removers is more effective. Describe in detail an experiment that person might perform in order to find out which spot remover is better for removing stains from fabrics. That person should find two old pieces of fabric made from the same material. The fabric doesn't be as only because if the stain isn't removed, they won't be as disappointed. The fabric should be made from the same material just in case one kind of material stains worse. Next put a stain on each piece of fabric (grape juice, spaghetti sauce) Let them sit for the same amount of time to make sure one doesn't stain worse because it sat longer. Then wash one with one spot remover and the other with the other spot remover. After they are washed the same way for the same amount of time, compare the stains. The person should buy the spot remover that removed the stain the best.

This works well plus it is a fun experiment to do!

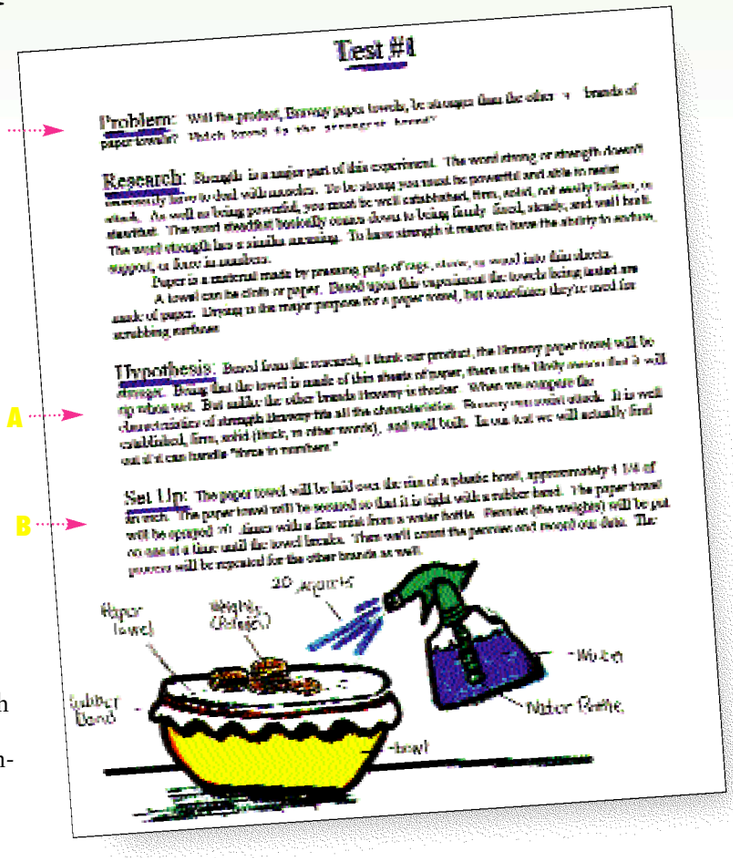
These work samples illustrate standard-setting performances for the following parts of the standards:

S5 a Scientific Thinking: Frame questions to distinguish cause and effect; identify or control variables in experimental and non-experimental research settings.

S7 d 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 92-95.

Work Sample & Commentary: *Paper Towels*



Test #1

Problem: Will the product, Bravery paper towels, be stronger than the other [illegible] brands of paper towels? Which brand is the strongest brand?

Research: Strength is a major part of this experiment. The word strong or strength doesn't necessarily have to deal with muscles. To be strong you must be powerful and able to resist attack. As well as being powerful, you must be well established, firm, solid, not easily broken, or shattered. The word strength basically means down to being sturdy, fixed, steady, and well built. The word strength has a similar meaning. To have strength it means to have the ability to endure, support, or force in numbers.

Paper is a material made by pressing pulp of rags, straw, or wood into flat sheets.

A towel can be cloth or paper. Based upon this experiment the towels being tested are made of paper. Drying is the major purpose for a paper towel, but sometimes they're used for scrubbing surfaces.

Hypothesis: Based from the research, I think our product, the Bravery paper towel, will be stronger. Being that the towel is made of thin sheets of paper, there is the likely chance that it will rip when wet. But unlike the other brands Bravery is thicker. When we compare the characteristics of strength Bravery fits all the characteristics. Bravery can resist attack. It is well established, firm, solid (thick, in other words), and well built. In our test we will actually find out if it can handle "stress in numbers."

Set Up: The paper towel will be laid over the rim of a plastic bowl, approximately 4 1/4 of an inch. The paper towel will be secured so that it is tight with a rubber band. The paper towel will be sprayed [illegible] times with a fine mist from a water bottle. Pennies (the weights) will be put on one at a time until the towel breaks. Then we'll count the pennies and record our data. The process will be repeated for the other brands as well.

The task

Students in a physical science class were asked to test the effectiveness of one of several different common products. The task required them to perform detailed and accurate testing and report results in a form for public presentation. Further, the students were asked to design and give a presentation promoting the most successful product.

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

Students had two weeks to complete the task which was part of a unit on scientific methodologies. While students videotaped a portion of their presentation, it is not included here.

Science required by the task

Paper towel testing is a common middle school activity, but many students select variables that are social in nature (e.g., cost, appearance) and are more easily measured than are strength or performance. This project tackled variables that required more imagination and effort to measure.

What the work shows

S4 a Scientific Connections and Applications: The student produces evidence that demonstrates understanding of big ideas and unifying concepts, such as…form and function….

A The student related the thickness (form) of towels to the characteristic of strength (function).

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

- **S4 a Scientific Connections and Applications: Big ideas and unifying concepts.**
- **S4 b Scientific Connections and Applications: The designed world.**
- **S5 a Scientific Thinking: Frame questions to distinguish cause and effect; identify or control variables in experimental or non-experimental research settings.**
- **S7 a Scientific Communication: Represent data and results in multiple ways.**
- **S8 a Scientific Investigation: Controlled experiment.**

The quotations from the Science performance descriptions in this commentary are excerpted. The complete performance descriptions are shown on pages 92-95.

Physical Sciences Concepts
Life Sciences Concepts
Earth and Space Sciences Concepts
Scientific Connections and Applications S4
Scientific Thinking S5
Scientific Tools and Technologies
Scientific Communication S7
Scientific Investigation S8

S4 b Scientific Connections and Applications: The student produces evidence that demonstrates understanding of the designed world, such as…the viability of technological designs.

A The student provided evidence of thinking through the design of paper towels and how well they would serve the intended purpose.

S5 a Scientific Thinking: The student frames questions to distinguish cause and effect; and identifies or controls variables in experimental and non-experimental research settings.

B C There is ample evidence of the student's recognition and control of variables.

S7 a Scientific Communication: The student represents data and results in multiple ways, such as numbers, tables…drawings, diagrams, and artwork….

B C The experimental set-up is communicated in both words and drawings.

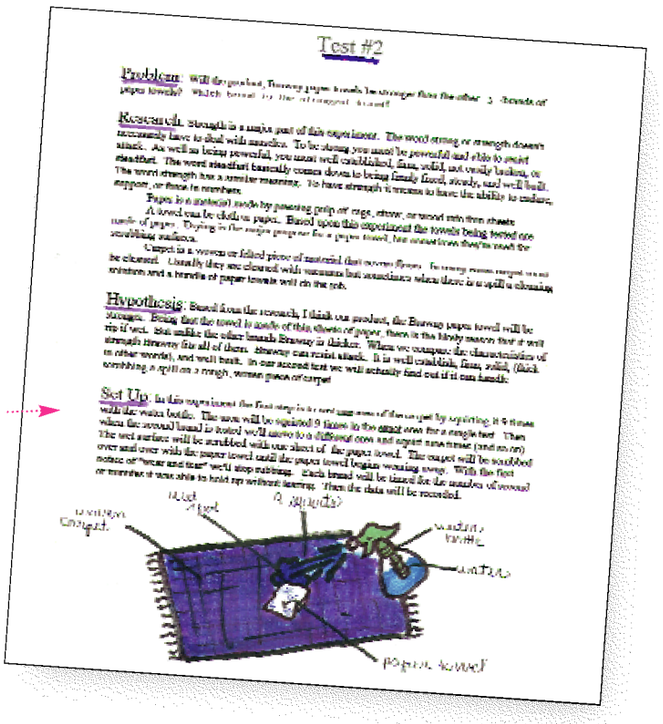
D E The results are communicated in tables, graphs, and words. The histogram is more effective than the pie chart. There is a reversal in the table for Test #2 (data for "Job Squad" and "Bounty"), but the multiple representations actually allow the reader to figure that out.

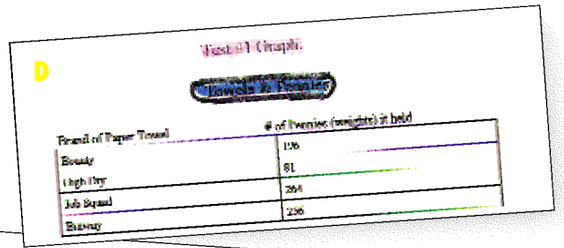
S8 a Scientific Investigation: The student demonstrates scientific competence by completing a controlled experiment. A full investigation includes:

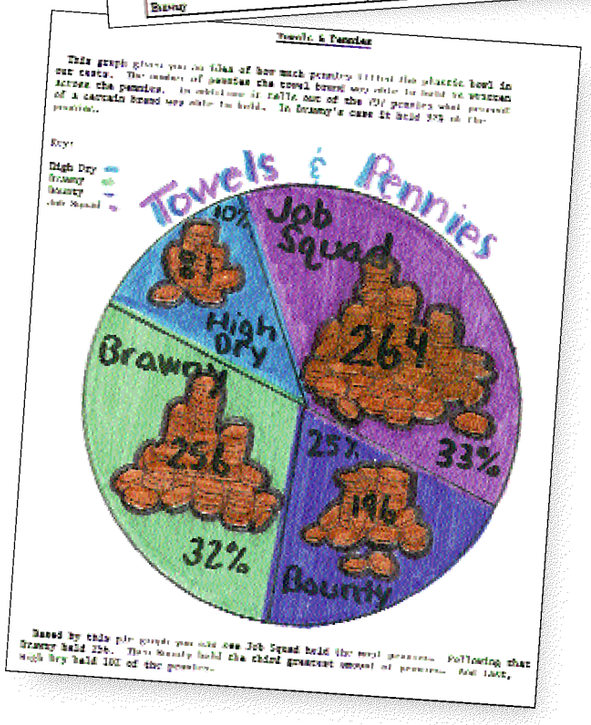
- Questions that can be studied using the resources available.

F

Paper Towels







- Procedures that are safe, humane, and ethical; and 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).

B C D E

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

D E

- Recommendations, decisions, and conclusions based on evidence.

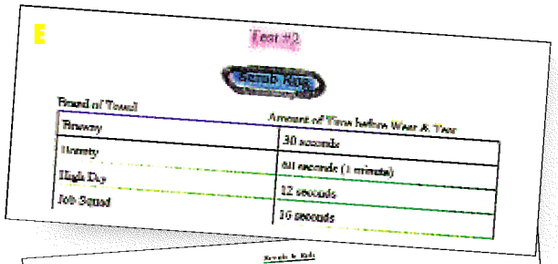
G

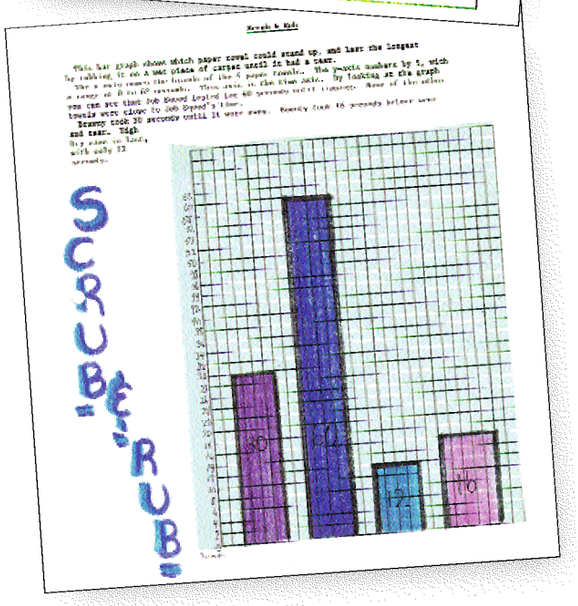
- Results that are communicated appropriately to audiences.

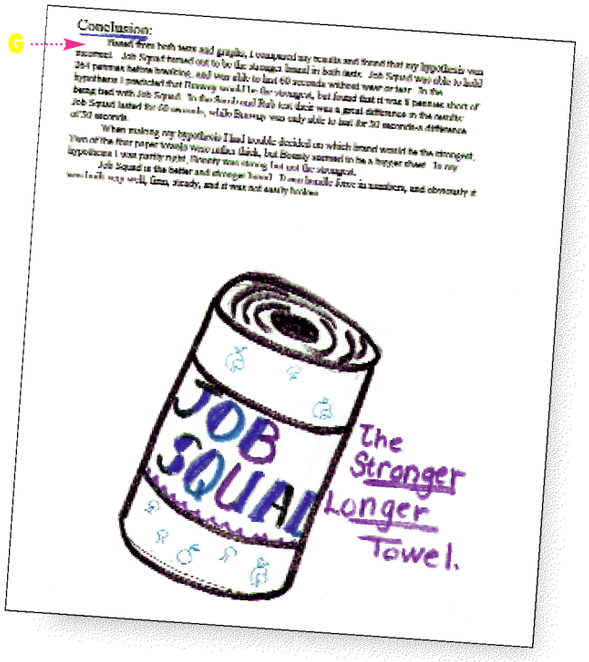
G

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

The student presented the work to others, though evidence of the presentation is not shown here.







Physical Sciences Concepts
Life Sciences Concepts
Earth and Space Sciences Concepts
S4 Scientific Connections and Applications
S5 Scientific Thinking
Scientific Tools and Technologies
S7 Scientific Communication
S8 Scientific Investigation