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ABSTRACT

This document contains Wisconsin's Model Academic Standards for Science. The Wisconsin Model Academic Standards for Science follow the format and the content of the National Science Education Standards. Three of the content standards address the knowledge-base of science while other content standards address the application of knowledge. These standards reflect the change and reform taking place in science education. Sample tasks and student work designed according to the standards are presented. Standards are presented for eight areas: (1) Science Connections; (2) Nature of Science; (3) Science Inquiry; (4) Physical Science; (5) Earth and Space Science; (6) Life and Environmental Science; (7) Science Applications; and (8) Science in Social and Personal Perspectives. Contains a glossary. (ASK)

WISCONSIN'S MODEL ACADEMIC STANDARDS FOR *Science*

Wisconsin's Model Academic Standards for Science

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*Established by Governor Tommy G. Thompson, January 29, 1997

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A Letter From the Lieutenant Governor and the State Superintendent

To the Citizens of Wisconsin:

On behalf of the Governor's Council on Model Academic Standards, it is our pleasure to present Wisconsin's Model Academic Standards in the area of science at grades four (4), eight (8), and twelve (12). Wisconsin has long been a model for other states in terms of educational quality. However, the world is rapidly becoming a more complex and challenging place. As a result, we must expect greater academic achievement from our children today if they are to be adequately prepared for the challenges of tomorrow. While Wisconsin's Model Academic Standards do demand more of our children, we are confident that they are equal to the task.

These standards are also significant because they herald the dramatically different way in which student achievement will be judged. In the past, achievement was determined by comparing a student's grades to those of his or her peers. In the future, mastery of subject matter will be objectively measured against these new standards at grades four, eight, and twelve. In this way we will know how well a student is learning, not how well that student is doing compared to others.

These model academic standards represent the work of writing teams made up of people from diverse backgrounds. Drafts were subjected to extensive public engagement in which hundreds of additional people offered input. The process of reaching consensus yielded a draft that enjoys very strong public support. Over 74 percent of respondents agreed or strongly agreed that the standards will prepare students for the future. Seventy percent felt they are sufficiently rigorous. Nearly 70 percent agreed or strongly agreed that they are clearly understandable and specific enough to guide local curricula and standards.

It must be stressed that these standards are not intended to limit local districts. Instead they are a model to be met or exceeded. The Council specifically encouraged local districts to implement standards that are more rigorous. However, districts must remember that assessment, including high school graduation exams based on standards, awaits every student in Wisconsin.

In closing, we want to commend the many members of the writing work groups. These teams, comprised of parents, teachers, business people, school board members, and administrators, gave freely of their time to produce the initial drafts. Finally, the citizens of Wisconsin must be thanked for devoting their time and effort to the development of the final draft of Wisconsin's Model Academic Standards.

Scott McCallum

Scott McCallum, Lt. Governor

John T. Benson

John T. Benson, State Superintendent

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Introduction

Defining the Academic Standards

What are academic standards? Academic standards specify what students should know and be able to do, what they might be asked to do to give evidence of standards, and how well they must perform. They include content, performance, and proficiency standards.

— Content standards refer to *what* students should know and be able to do.

— Performance standards tell *how* students will show that they are meeting a standard.

— Proficiency standards indicate *how well* students must perform.

Why are academic standards necessary? Standards serve as rigorous goals for teaching and learning. Setting high standards enables students, parents, educators, and citizens to know what students should have learned at a given point in time. The absence of standards has consequences similar to lack of goals in any pursuit. Without clear goals, students may be unmotivated and confused.

Contemporary society is placing immense academic demands on students. Clear statements about what students must know and be able to do are essential to ensure that our schools offer students the opportunity to acquire the knowledge and skills necessary for success.

Why are state-level academic standards important? Public education is a state responsibility. The state superintendent and legislature must ensure that all children have equal access to high quality educational programs. At a minimum, this requires clear statements of what all children in the state should know and be able to do as well as evidence that students are meeting these expectations. Furthermore, academic standards form a sound basis on which to establish the content of a statewide assessment system.

Why does Wisconsin need its own academic standards? Historically, the citizens of Wisconsin are very serious and thoughtful about education. They expect and receive very high performance from their schools. While educational needs may be similar among states, values differ. Standards should reflect the collective values of the citizens and be tailored to prepare young people for economic opportunities that exist in Wisconsin, the nation, and the world.

Developing the Academic Standards

How were Wisconsin's model academic standards developed? Citizens throughout the state developed the academic standards. The first phase involved educators, parents, board of education members, and business and industry people who produced preliminary content and performance standards in 12 subjects including English language arts, mathematics, science, social studies, visual arts, music, theatre, dance, family and consumer education, foreign language, health education, and physical education. These standards are benchmarked to the end of grades 4, 8, and 12.

The next step required public input aimed at getting information to revise and improve the preliminary standards. This effort included forums and focus groups held throughout the state. The state superintendent used extensive media exposure, including telecommunications through the DPI home page, to ensure the widest possible awareness and participation in standards development.

Each subject had at least two drafts taken to the general public for their review. Based on this input, the standards were revised to reflect the values of Wisconsin's citizens.

In January 1997, Governor Thompson appointed the Governor's Council on Model Academic Standards. The Council augmented the existing Department of Public Instruction task forces with additional appointees by the Council, these newly configured task forces produced another draft of model academic standards for the subjects that are part of the state assessment system. These include English language arts, mathematics, reading, science, and social studies.

Once these draft standards were completed, public review became the focus. Using a series of statewide forums coupled with a wide mailing distribution and telecommunications access through both the Wisconsin Department of Public Instruction and the lieutenant governor's home pages, Wisconsin citizens provided valuable feedback. As with previous drafts, all comments received serious consideration.

Who wrote the academic standards and what resources were used? Each subject area's academic standards were drafted by teams of educators, parents, board of education members, and business and industry people that were sub-groups of larger task forces. This work was done after reviewing national standards in the subject area, standards from other states, standards from local Wisconsin school districts, and standards like the nationwide New Standards Project.

After the creation of the Governor's Council on Model Academic Standards, four task forces representing English language arts (reading was folded into this group) mathematics, science, and social studies were appointed. Combining the existing DPI task force members with the Council's appointees further ensured that the many voices of Wisconsin's citizenry were represented through the parents, educators, school board members, and business and industry people sitting on those task forces. Documents reviewed included the national standards in the subject area, standards from other states, and standards from local Wisconsin schools. The two most frequently used resources were the first and second drafts of content and performance standards developed by the DPI and the Modern Red Schoolhouse standards developed by the Hudson Institute and Dr. Finley McQuade.

How was the public involved in the standards process? The DPI was involved in extensive public engagement activities to gather citizen input on the first two drafts of the academic standards. Over 19 focus group sessions, 17 community forums, and more than 450 presentations at conferences, conventions, and workshops were held. More than 500,000 paper copies of the standards tabloids were distributed across the state in addition to more than 4,000 citizen visits to the standards on the DPI web page. Input from these activities, along with more than 90 reviews by state and national organizations, provided the writers with feedback on Wisconsin's model academic standards.

Continuing the emphasis on public engagement started by the DPI with previous standards drafts, the Governor's Council on Model Academic Standards held nine community forums. In addition, more than 50,000 paper copies of the standards were distributed. Recipients included each public school building as well as all major education stakeholders and interest groups. Lending the prestige of their offices to the standards development, members of the Council met with editorial boards of media outlets throughout the state discussing the model academic standards.

Will academic standards be developed in areas other than the 12 areas listed above? Yes, currently the DPI has convened six task forces to develop academic standards in agriculture, business, environmental education, marketing, technology education, and information and technology literacy. Task force members include educators, parents, school board members, and representatives of business and industry. These academic standards will be completed by the start of the 1998-99 school year.

Using the Academic Standards

How will the Department of Public Instruction use the Wisconsin Model Academic Standards? Upon completing its work, the Governor's Council on Model Academic Standards submitted academic content and performance standards for English language arts, mathematics, science, and social studies to the governor. On January 13, 1998, Governor Thompson signed Executive Order 326, thus approving and issuing the model academic and performance standards developed by the Governor's Council. These approved standards will be used as the basis for state testing, especially as it relates to the Wisconsin Reading Comprehension Test, the Wisconsin Student Assessment System, and the planned High School Graduation Test.

Additionally, the DPI will use the Wisconsin Model Academic Standards as the basis for revision of its *Guides to Curriculum Planning* and as the foundation for professional development activities that it sponsors.

Must a district adopt the Wisconsin Model Academic Standards? Adopting the Wisconsin Model Academic Standards is voluntary, not mandatory. Districts, however, must have academic standards in place by August 1, 1998. At a minimum, districts are required to have standards in reading and writing, geography and history, mathematics, and science. Districts may adopt the model state standards, or standards from other sources, or develop their own standards.

How will local districts use the academic standards? Districts may use the academic standards as guides for developing local grade-by-grade level curriculum. Implementing standards may require some school districts to upgrade school and district curriculums. In some cases, this may result in significant changes in instructional methods and materials, local assessments, and professional development opportunities for the teaching and administrative staff.

What is the difference between academic standards and curriculum? Standards are statements about what students should know and be able to do, what they might be asked to do to give evidence of learning, and how well they should be expected to know or do it. Curriculum is the program devised by local school districts used to prepare students to meet standards. It consists of activities and lessons at each grade level, instructional materials, and various instructional techniques. In short, standards define what is to be learned at certain points in time, and from a broad perspective, what performances will be accepted as evidence that the learning has occurred. Curriculum specifies the details of the day-to-day schooling at the local level.

What is the link between statewide academic standards and statewide testing? Statewide academic standards in mathematics, English language arts, science, and social studies determine the scope of statewide testing. While these standards are much broader in content than any single Wisconsin Student Assessment System (WSAS) test, they do describe the range of knowledge and skills that may appear on the tests. If content does not appear in the academic standards, it will not be part of a WSAS test. The statewide standards clarify what must be studied to prepare for WSAS tests. If students have learned all of the material indicated by the standards in the assessed content areas, they should do very well on the state tests.

Relating the Academic Standards to All Students

Parents and educators of students with disabilities, with limited English proficiency (LEP), and with accelerated needs may ask why academic standards are important for their students. Academic standards serve as a valuable basis for establishing meaningful goals as part of each student's developmental progress and demonstration of proficiency. The clarity of academic standards provides meaningful, concrete goals for the achievement of students with exceptional education needs (EEN), LEP, and accelerated needs consistent with all other students.

Academic standards may serve as the foundation for individualized programming decisions for students with EEN, LEP, and accelerated needs. While the vast majority of students with EEN and LEP should be expected to work toward and achieve these standards, accommodations and modifications to help these students reach the achievement goals will need to be individually identified and implemented. For students with EEN, these decisions are made as part of their individualized education program (IEP) plans. Accelerated students may achieve well beyond the academic standards and move into advanced grade levels or into advanced coursework.

Clearly, these academic standards are for all students. As our state assessments are aligned with these standards and school districts adopt, adapt, or develop their own standards and multiple measures for determining proficiencies of students, greater accountability for the progress of all students can be assured. In Wisconsin this means all students reaching their full individual potential, every school being accountable, every parent a welcomed partner, every community supportive, and no excuses.

Applying the Academic Standards Across the Curriculum

When community members and employers consider what they want citizens and employees to know and be able to do, they often speak of broad areas of applied knowledge such as communication, thinking, problem solving, and decision making. These areas connect or go beyond the mastery of individual subject areas. As students apply their knowledge both within and across the various curricular areas, they develop the concepts and complex thinking of educated persons.

Community members need these skills to function as responsible citizens. Employers prize those employees who demonstrate these skills because they are people who can continue learning and connect what they have learned to the requirements of a job. College and university faculty recognize the need for these skills as the means of developing the level of understanding that separates the expert from the beginner.

Teachers in every class should expect and encourage the development of these shared applications, both to promote the learning of the subject content and to extend learning across the curriculum. These applications fall into five general categories:

1) Application of the Basics

2) Ability to Think
   - Problem solving
   - Informed decision making
   - Systems thinking
   - Critical, creative, and analytical thinking
   - Imagining places, times, and situations different from one's own
   - Developing and testing a hypothesis
   - Transferring learning to new situations

3) Skill in Communication
   - Constructing and defending an argument
   - Working effectively in groups
   - Communicating plans and processes for reaching goals
   - Receiving and acting on instructions, plans, and models
   - Communicating with a variety of tools and skills

4) Production of Quality Work
   - Acquiring and using information
   - Creating quality products and performances
   - Revising products and performances
   - Developing and pursuing positive goals

5) Connections with Community
   - Recognizing and acting on responsibilities as a citizen
   - Preparing for work and lifelong learning
   - Contributing to the aesthetic and cultural life of the community
   - Seeing oneself and one's community within the state, nation, and world
   - Contributing and adapting to scientific and technological change

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Overview of Science

The study of science allows Wisconsin students to experience the richness and excitement of the natural world. As adults they will face complex questions requiring scientific thinking, reasoning, and the ability to make informed decisions. Scientific knowledge prepares students for the future and helps them acquire skills needed to hold meaningful and productive jobs. These standards recognize that science is for all students—the essence of science literacy.

Clarity and Specificity

Citizens of Wisconsin are the primary audience for the science standards. The standards set clear and specific goals for teaching and learning, and they are not meant to supplant curriculum. Instead, they should help school districts to develop curriculum units that focus on specific academic results. Districts are encouraged to engage in professional conversations suggested by this document and by the National Science Education Standards* (see Glossary of Terms). Parents and other citizens in the district should be a part of this conversation.

The Wisconsin Model Academic Standards for Science follow the format and content of the *National Science Education Standards**. Three of the content standards (D. Physical Science, E. Earth and Space Science, and F. Life and Environmental Science) address the knowledge-base of science, while the other content standards address the application of knowledge. A reader looking for more of the details inherent in the content standards may refer to the *National Science Education Standards**.

Advanced Science Content

Not all students will elect to pursue the more advanced science courses often considered college preparatory or advanced placement courses (Physics II, for example). The science standards do not represent the level of achievement expected in these higher level courses. Rather, they try to capture the knowledge and skills needed to be a scientifically literate citizen.

Examples of Science in Wisconsin

These standards reflect change and reform taking place in science education. They recognize that students and teachers learn together. They also illustrate that science education is an active process that embodies intellectual and cultural traditions important in the practice of contemporary science. Such traditions are honored in every school district in Wisconsin. School districts are encouraged to incorporate the richness of their state and local area in a curriculum aimed at achieving the standards.

Connectedness

Although the standards illustrate the importance of content in earth and space, life and environmental, and physical sciences, they also reflect the interconnectedness of science through inquiry, communication, and applications. Each standard is connected to other standards so that the student gains a better understanding of science through a systemic approach to learning. Further, this interconnectedness of the sciences can be applied to all areas of learning. Students and teachers are encouraged to work together by using inquiry methods each day of class instruction.

Continuity

It is assumed that standards achieved at early levels will be maintained and developed at later levels. To avoid repetition, knowledge and skills that first appear by grade four may not be repeated at subsequent levels, even though students are expected to retain them.

Safety

Safety is a fundamental concern in all experimental science when asking students to perform experiments. Teachers of science must know and apply the necessary safety regulations in the use, storage, and care of materials used by students. Safety while learning science requires thorough planning, management, and continuous monitoring of student activities both at school and during any science-related activities. Students must also take responsibility for their own safety and perform experiments as instructed.

[In the text that follows, terms with an asterisk (*) are defined and/or exemplified in the Glossary of Terms following the science standards.]

A. SCIENCE CONNECTIONS

CONTENT STANDARD

Students in Wisconsin will understand that among the science disciplines, there are unifying themes: systems, order, organization, and interactions; evidence, models, and explanations; constancy, change, and measurement; evolution, equilibrium, and energy; and form and function.

These themes relate and interconnect the Wisconsin science standards to one another. Each theme is further defined in the glossary following the science standards.

Rationale: These unifying themes are ways of thinking rather than theories or discoveries. Students should know about these themes and realize that the more they learn about science the better they will understand how the themes organize and enlarge their knowledge. Science is a system and should be seen as a single discipline rather than a set of separate disciplines. Students will also understand science better when they connect and integrate these unifying themes into what they know about themselves and the world around them.

PERFORMANCE STANDARDS

BY THE END OF GRADE 4 STUDENTS WILL:

A.4.1 When conducting science investigations*, ask and answer questions that will help decide the general areas of science being addressed

A.4.2 When faced with a science-related problem, decide what evidence*, models*, or explanations* previously studied can be used to better understand* what is happening now

A.4.3 When investigating* a science-related problem, decide what data can be collected to determine the most useful explanations*

A.4.4 When studying science-related problems, decide which of the science themes* are important

A.4.5 When studying a science-related problem, decide what changes* over time are occurring or have occurred

*Terms with an asterisk are defined in the Glossary of Terms.

BY THE END OF GRADE 8 STUDENTS WILL:

A.8.1 Develop their understanding of the science themes* by using the themes to frame questions about science-related issues and problems

A.8.2 Describe* limitations of science systems* and give reasons why specific science themes* are included in or excluded from those systems

A.8.3 Defend explanations* and models* by collecting and organizing evidence* that supports them and critique explanations and models by collecting and organizing evidence that conflicts with them

A.8.4 Collect evidence* to show* that models* developed as explanations* for events were (and are) based on the evidence available to scientists at the time

A.8.5 Show* how models* and explanations*, based on systems*, were changed as new evidence* accumulated (the effects of constancy*, evolution*, change*, and measurement* should all be part of these explanations)

A.8.6 Use models* and explanations* to predict* actions and events in the natural world

A.8.7 Design real or thought investigations* to test the usefulness and limitations of a model*

A.8.8. Use the themes* of evolution*, equilibrium*, and energy* to predict* future events or changes* in the natural world

BY THE END OF GRADE 12 STUDENTS WILL:

A.12.1 Apply* the underlying themes* of science to develop defensible visions of the future

A.12.2 Show* how conflicting assumptions about science themes* lead to different opinions and decisions about evolution*, health, population, longevity, education, and use of resources, and show* how these opinions and decisions have diverse effects on an individual, a community, and a country, both now and in the future

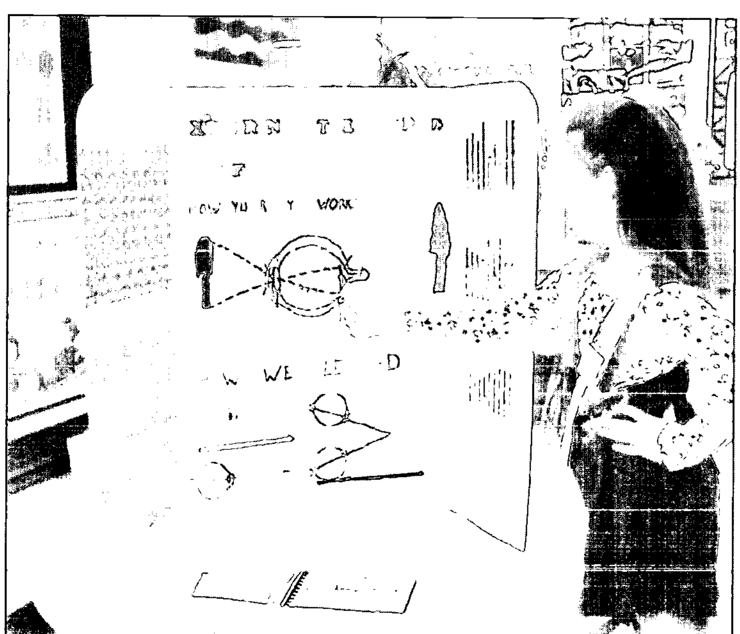
A.12.3 Give examples that show* how partial systems*, models*, and explanations* are used to give quick and reasonable solutions that are accurate enough for basic needs

A.12.4 Construct* arguments that show* how conflicting models* and explanations* of events can start with similar evidence*

A.12.5 Show* how the ideas and themes* of science can be used to make real-life decisions about careers, work places, life-styles, and use of resources

A.12.6 Identify* and replace inaccurate personal models* and explanations* of science-related phenomena using evidence* learned or discovered,

A.12.7 Re-examine the evidence* and reasoning that led to conclusions drawn from investigations*, using the science themes*



B. NATURE OF SCIENCE

CONTENT STANDARD

Students in Wisconsin will understand that science is ongoing and inventive, and that scientific understandings have changed over time as new evidence is found.

Rationale: Students will realize that scientific knowledge is developed from the activities of scientists and others who work to find the best possible explanations of the natural world. Researchers and those who are involved in science follow a generally accepted set of rules to produce scientific knowledge that others can confirm through experimentation. This knowledge is public, replicable, and undergoing revision and refinement based on new experiments and data.

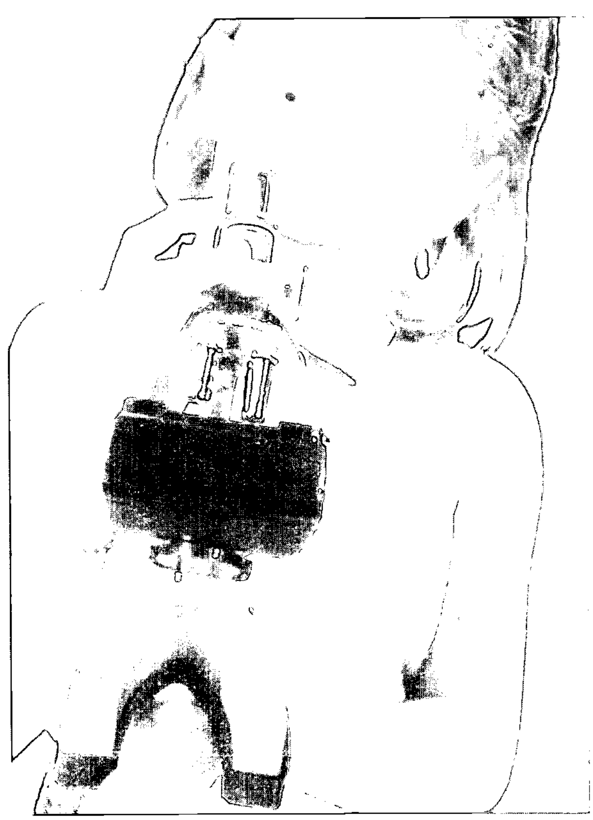
PERFORMANCE STANDARDS

BY THE END OF GRADE 4 STUDENTS WILL:

B.4.1 Use encyclopedias, source books, texts, computers, teachers, parents, other adults, journals, popular press, and various other sources, to help answer science-related questions and plan investigations

B.4.2 Acquire information about people who have contributed to the development of major ideas in the sciences and learn about the cultures in which these people lived and worked

B.4.3 Show* how the major developments of scientific knowledge in the earth and space, life and environmental, and physical sciences have changed over time



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*Terms with an asterisk are defined in the Glossary of Terms.

BY THE END OF GRADE 8 STUDENTS WILL:

B.8.1 Describe* how scientific knowledge and concepts have changed over time in the earth and space, life and environmental, and physical sciences

B.8.2 Identify* and describe* major changes that have occurred over time in conceptual models* and explanations* in the earth and space, life and environmental, and physical sciences, and identify* the people, cultures, and conditions that led to these developments

B.8.3 Explain* how the general rules of science apply to the development and use of evidence* in science investigations, model*-making, and applications*

B.8.4 Describe* types of reasoning and evidence* used outside of science to draw conclusions about the natural world

B.8.5 Explain* ways in which science knowledge is shared, checked, and extended, and show* how these processes change over time

B.8.6 Explain* the ways in which scientific knowledge is useful and also limited when applied to social issues

BY THE END OF GRADE 12 STUDENTS WILL:

B.12.1 Show* how cultures and individuals have contributed to the development of major ideas in the earth and space, life and environmental, and physical sciences

B.12.2 Identify* the cultural conditions that are usually present during great periods of discovery, scientific development, and invention

B.12.3 Relate* the major themes* of science to human progress in understanding science and the world

B.12.4 Show* how basic research and applied research contribute to new discoveries, inventions, and applications

B.12.5 Explain* how science is based on assumptions about the natural world and themes* that describe the natural world

C. SCIENCE INQUIRY

CONTENT STANDARD

Students in Wisconsin will investigate questions using scientific methods and tools, revise their personal understanding to accommodate knowledge, and communicate these understandings to others.

Rationale: Students should experience science in a form that engages them in actively constructing ideas and explanations and enhances their opportunities to develop the skills of doing science. Such inquiry (problem solving) should include questioning, forming hypotheses, collecting and analyzing data, reaching conclusions and evaluating results, and communicating procedures and findings to others.

PERFORMANCE STANDARDS

BY THE END OF GRADE 4 STUDENTS WILL:

C.4.1 Use the vocabulary of the unifying themes* to ask questions about objects, organisms, and events being studied

C.4.2 Use the science content being learned to ask questions, plan investigations*, make observations*, make predictions*, and offer explanations*

C.4.3 Select multiple sources of information to help answer questions selected for classroom investigations*

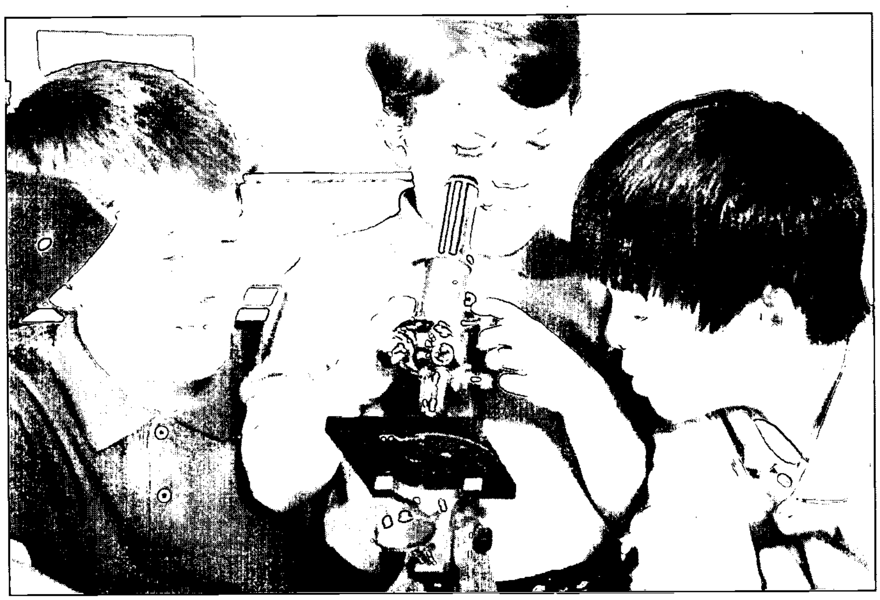
C.4.4 Use simple science equipment including rulers, balances, graduated cylinders, hand lenses, thermometers, and computers safely and effectively to collect data relevant to questions and investigations*

C.4.5 Use data they have collected to develop explanations* and answer questions generated by investigations*

C.4.6 Communicate the results of their investigations* in ways their audiences will understand by using charts, graphs, drawings, written descriptions, and various other means

C.4.7 Support their conclusions with logical arguments

C.4.8 Ask additional questions that might help focus or further an investigation*



*Terms with an asterisk are defined in the Glossary of Terms.

BY THE END OF GRADE 8 STUDENTS WILL:

C.8.1 Identify* questions they can investigate* using resources and equipment they have available

C.8.2 Identify* data and locate sources of information including their own records to answer the questions being investigated

C.8.3 Design and safely conduct investigations* that provide reliable quantitative or qualitative data, as appropriate, to answer their questions

C.8.4 Use inferences* to help decide possible results of their investigations, use observations to check their inferences

C.8.5 Use accepted scientific knowledge, models*, and theories* to explain* their results and to raise further questions about their investigations*

C.8.6 State what they have learned from investigations*, relating their inferences* to scientific knowledge and to data they have collected

C.8.7 Explain* their data and conclusions in ways that allow an audience to understand the questions they selected for investigation* and the answers they have developed

C.8.8 Use computer software and other technologies to organize, process, and present their data

C.8.9 Evaluate*, explain*, and defend the validity of questions, hypotheses, and conclusions to their investigations*

C.8.10 Discuss the importance of their results and implications of their work with peers, teachers, and other adults

C.8.11 Raise further questions which still need to be answered

BY THE END OF GRADE 12 STUDENTS WILL:

C.12.1 When studying science content, ask questions suggested by current social issues, scientific literature, and observations* of phenomena; build hypotheses that might answer some of these questions; design possible investigations*; and describe results that might emerge from such investigations

C.12.2 Identify* issues from an area of science study, write questions that could be investigated*, review previous research on these questions, and design and conduct responsible and safe investigations to help answer the questions

C.12.3 Evaluate* the data collected during an investigation*, critique the data-collection procedures and results, and suggest ways to make any needed improvements

C.12.4 During investigations*, choose the best data-collection procedures and materials available, use them competently, and calculate the degree of precision of the resulting data

C.12.5 Use the explanations* and models* found in the earth and space, life and environmental, and physical sciences to develop likely explanations* for the results of their investigations*

C.12.6 Present the results of investigations* to groups concerned with the issues, explaining* the meaning and implications of the results, and answering questions in terms the audience can understand

C.12.7 Evaluate* articles and reports in the popular press, in scientific journals, on television, and on the Internet, using criteria related to accuracy, degree of error, sampling, treatment of data, and other standards of experimental design

D. PHYSICAL SCIENCE

CONTENT STANDARD

Students in Wisconsin will demonstrate an understanding of the physical and chemical properties of matter, the forms and properties of energy, and the ways in which matter and energy interact.

Rationale: Knowledge of the physical and chemical properties of matter and energy is basic to an understanding of the earth and space, life and environmental, and physical sciences. The properties of matter can be explained in terms of the atomic structure of matter. Natural events are the result of interactions of matter and energy. When students understand how matter and energy interact, they can explain and predict chemical and physical changes that occur around them.

For more details of the content of life and environmental sciences, see

National Science Education Standards (1996, p. 115 - 201), Washington, D.C., National Academy Press.

PERFORMANCE STANDARDS

BY THE END OF GRADE 4 STUDENTS WILL:

Properties of Earth Materials

D.4.1 Understand* that objects are made of more than one substance, by observing, describing, and measuring the properties of earth materials, including properties of size, weight, shape, color, temperature, and the ability to react with other substances

D.4.2 Group* and/or classify objects and substances based on the properties of earth materials

D.4.3. Understand* that substances can exist in different states—solid, liquid, gas

D.4.4 Observe* and describe* changes* in form, temperature, color, speed, and direction of objects and construct* explanations* for the changes

D.4.5 Construct* simple models* of what is happening to materials and substances undergoing change*, using simple instruments or tools to aid observations and collect data

Position and Motion of Objects

D.4.6 Observe* and describe* physical events in objects at rest or in motion

D.4.7 Observe* and describe* physical events involving objects and develop record-keeping systems to follow these events by measuring and describing changes in their properties, including position relative to another object, motion over time, and position due to forces

Light, Heat, Electricity, and Magnetism

D.4.8 Ask questions and make observations to discover* the differences between substances that can be touched (matter) and substances that cannot be touched (forms of energy, light, heat, electricity, sound, and magnetism)

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*Terms with an asterisk are defined in the Glossary of Terms.

BY THE END OF GRADE 8 STUDENTS WILL:

Properties and Changes of Properties in Matter

D.8.1 Observe*, describe*, and measure* physical and chemical properties of elements and other substances to identify* and group* them according to properties such as density, melting points, boiling points, conductivity, magnetic attraction, solubility, and reactions to common physical and chemical tests

D.8.2 Use the major ideas of atomic theory and molecular theory to describe* physical and chemical interactions* among substances, including solids, liquids, and gases

D.8.3 Understand* how chemical interactions* and behaviors lead to new substances with different properties

D.8.4 While conducting investigations*, use the science themes* to develop explanations* of physical and chemical interactions* and energy* exchanges

Motions and Forces

D.8.5 While conducting investigations*, explain* the motion of objects by describing* the forces acting on them

D.8.6 While conducting investigations*, explain* the motion of objects using concepts of speed, velocity, acceleration, friction, momentum, and changes over time, among others, and apply* these concepts and explanations* to real-life situations outside the classroom

D.8.7 While conducting investigations* of common physical and chemical interactions* occurring in the laboratory and the outside world, use commonly accepted definitions of energy* and the idea of energy conservation

Transfer of Energy

D.8.8 Describe* and investigate* the properties of light, heat, gravity, radio waves, magnetic fields, electrical fields, and sound waves as they interact* with material objects in common situations

D.8.9 Explain* the behaviors of various forms of energy* by using the models* of energy transmission, both in the laboratory and in real-life situations

D.8.10 Explain* how models* of the atomic structure of matter have changed over time, including historical models and modern atomic theory

BY THE END OF GRADE 12 STUDENTS WILL:

Structures of Atoms and Matter

D.12.1 Describe* atomic structure and the properties of atoms, molecules, and matter during physical and chemical interactions*

D12.2 Explain* the forces that hold the atom together and illustrate* how nuclear interactions* change the atom

D.12.3 Explain* exchanges of energy* in chemical interactions* and exchange of mass and energy in atomic/nuclear reactions

Chemical Reactions

D.12.4 Explain* how substances, both simple and complex, interact* with one another to produce new substances

D.12.5 Identify* patterns in chemical and physical properties and use them to predict* likely chemical and physical changes and interactions

D.12.6 Through investigations*, identify* the types of chemical interactions*, including endothermic, exothermic, oxidation, photosynthesis, and acid/base reactions

Motions and Forces

D.12.7 Qualitatively and quantitatively analyze* changes in the motion of objects and the forces that act on them and represent analytical data both algebraically and graphically

D.12.8 Understand* the forces of gravitation, the electromagnetic force, intermolecular force, and explain* their impact on the universal system

D.12.9 Describe* models* of light, heat, and sound and through investigations* describe* similarities and differences in the way these energy* forms behave

Conservation of Energy and the Increase in Disorder

D.12.10 Using the science themes*, illustrate* the law of conservation of energy* during chemical and nuclear reactions

Interactions of Matter and Energy

D.12.11 Using the science themes*, explain* common occurrences in the physical world

D.12.12 Using the science themes* and knowledge of chemical, physical, atomic, and nuclear interactions*, explain* changes in materials, living things, earth's features, and stars

E. EARTH AND SPACE SCIENCE

CONTENT STANDARD

Students in Wisconsin will demonstrate an understanding of the structure and systems of the earth and other bodies in the universe and their interactions.

Rationale: By studying the earth, its composition, history, and the processes that shape it, students gain a better understanding of the planet on which they live. Understanding these geologic, meteorological, astronomical, and oceanographic processes allows students to make responsible choices and to evaluate the consequences of their choices. In addition, all bodies in space, including the earth, are influenced by forces acting through-out the solar system and the universe. Studying the universe enhances students' understanding of the earth's origins, its place in the universe, and its future.

For more details of the content of life and environmental sciences, see

National Science Education Standards (1996, p. 115 - 201), Washington, D.C., National Academy Press.

PERFORMANCE STANDARDS

BY THE END OF GRADE 4 STUDENTS WILL:

Properties of Earth Materials

E.4.1 Investigate* that earth materials are composed of rocks and soils and correctly use the vocabulary for rocks, minerals, and soils during these investigations

E.4.2 Show* that earth materials have different physical and chemical properties, including the properties of soils found in Wisconsin

E.4.3 Develop descriptions* of the land and water masses of the earth and of Wisconsin's rocks and minerals, using the common vocabulary of earth and space science

Objects in the Sky

E.4.4 Identify* celestial objects (stars, sun, moon, planets) in the sky, noting changes in patterns of those objects over time

Changes in the Earth and Sky

E.4.5 Describe* the weather commonly found in Wisconsin in terms of clouds, temperature, humidity, and forms of precipitation, and the changes* that occur over time, including seasonal changes

E.4.6 Using the science themes*, find patterns and cycles in the earth's daily, yearly, and long-term changes*

E.4.7 Using the science themes*, describe* resources used in the home, community, and nation as a whole

E.4.8 Illustrate* resources humans use in mining, forestry, farming, and manufacturing in Wisconsin and elsewhere in the world

*Terms with an asterisk are defined in the Glossary of Terms.

BY THE END OF GRADE 8 STUDENTS WILL:

Structure of Earth System

E.8.1 Using the science themes*, explain* and predict* changes* in major features of land, water, and atmospheric systems

E.8.2 Describe* underlying structures of the earth that cause changes* in the earth's surface

E.8.3 Using the science themes* during investigations*, describe* climate, weather, ocean currents, soil movements, and changes* in the forces acting on the earth

E.8.4 Using the science themes*, analyze* the influence living organisms have had on the earth's systems, including their impact on the composition of the atmosphere and the weathering of rocks

Earth's History

E.8.5 Analyze* the geologic and life history of the earth, including change* over time, using various forms of scientific evidence

E.8.6 Describe* through investigations the use of the earth's resources by humans in both past and current cultures, particularly how changes in the resources used for the past 100 years are the basis for efforts to conserve and recycle renewable and nonrenewable resources

Earth in the Solar System

E.8.7 Describe* the general structure of the solar system, galaxies, and the universe, explaining the nature of the evidence* used to develop current models* of the universe

E.8.8 Using past and current models* of the structure of the solar system, explain* the daily, monthly, yearly, and long-term cycles of the earth, citing evidence* gained from personal observation* as well as evidence used by scientists

BY THE END OF GRADE 12 STUDENTS WILL:

Energy in the Earth System

E. 12.1 Using the science themes*, distinguish between internal energies* (decay of radioactive isotopes, gravity) and external energies (sun) in the earth's systems and show* how these sources of energy have an impact on those systems

Geochemical Cycles

E.12.2 Analyze* the geochemical and physical cycles of the earth and use them to describe* movements of matter

The Origin and Evoluation of the Earth System

E.12.3 Using the science themes*, describe* theories of the origins and evolution* of the universe and solar system, including the earth system* as a part of the solar system, and relate* these theories and their implications to geologic time on the earth

E.12.4 Analyze* the benefits, costs, and limitations of past, present, and projected use of resources and technology and explain* the consequences to the environment

The Origin and Evolution of the Universe

E.12.5 Using the science themes*, understand* that the origin of the universe is not completely understood, but that there are current ideas in science that attempt to explain its origin

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F. LIFE AND ENVIRONMENTAL SCIENCE

CONTENT STANDARD

Students in Wisconsin will demonstrate an understanding of the characteristics and structures of living things, the processes of life, and how living things interact with one another and their environment.

Rationale: Students will enhance their natural curiosity about living things and their environment through study of the structure and function of living things, ecosystems, life cycles, energy movement (transfer), energy change (transformation), and changes in populations of organisms through time. Knowledge of these concepts and processes of life and environmental science will assist students in making informed choices regarding their lifestyles and the impact they have on communities of living things in their environment.

For more details of the content of life and environmental sciences, see

National Science Education Standards (1996, p. 115 - 201), Washington, D.C., National Academy Press.

PERFORMANCE STANDARDS

BY THE END OF GRADE 4 STUDENTS WILL:

The Characteristics of Organisms

F.4.1 Discover* how each organism meets its basic needs for water, nutrients, protection, and energy* in order to survive

F.4.2 Investigate* how organisms, especially plants, respond to both internal cues (the need for water) and external cues (changes in the environment)

Life Cycles of Organisms

F.4.3 Illustrate* the different ways that organisms grow through life stages and survive to produce new members of their type

Organisms and Their Environment

F.4.4 Using the science themes*, develop explanations* for the connections among living and nonliving things in various environments

*Terms with an asterisk are defined in the Glossary of Terms.

BY THE END OF GRADE 8 STUDENTS WILL:

Structure and Function in Living Things

F.8.1 Understand* the structure and function* of cells, organs, tissues, organ systems, and whole organisms

F.8.2 Show* how organisms have adapted structures to match their functions*, providing means of encouraging individual and group survival within specific environments

F.8.3 Differentiate between single-celled and multiple-celled organisms (including humans) through investigations, comparing the cell functions of specialized cells for each type of organism

Reproduction and Heredity

F.8.4 Investigate* and explain* that heredity is comprised of the characteristic traits found in genes within the cell of an organism

F.8.5 Show* how different structures both reproduce and pass on characteristics of their group

Regulation and Behavior

F.8.6 Understand* that an organism is regulated both internally and externally

F.8.7 Understand* that an organism's behavior evolves through adaptation to its environment

Populations and Ecosystems

F.8.8 Show* through investigations* how organisms both depend on and contribute to the balance or imbalance of populations and/or ecosystems, which in turn contribute to the total system* of life on the planet

Diversity and Adaptations of Organisms

F.8.9 Explain* how some of the changes* on the earth are contributing to changes in the balance of life and affecting the survival or population growth of certain species

F.8.10 Project how current trends in human resource use and population growth will influence the natural environment, and show how current policies affect those trends

BY THE END OF GRADE 12 STUDENTS WILL:

The Cell

F.12.1 Evaluate* the normal structures and the general and special functions* of cells in single-celled and multiple-celled organisms

F.12.2 Understand* how cells differentiate and how cells are regulated

The Molecular Basis of Heredity

F.12.3 Explain* current scientific ideas and information about the molecular and genetic basis of heredity

F.12.4 State the relationships between functions* of the cell and functions of the organism as related to genetics and heredity

*Biological Evoluation**

F.12.5 Understand* the theory of evolution*, natural selection, and biological classification

F.12.6 Using concepts of evolution* and heredity, account for changes* in species and the diversity of species, include the influence of these changes on science, e.g., breeding of plants or animals

The Interdependence of Organisms

F.12.7 Investigate* how organisms both cooperate and compete in ecosystems

F.12.8 Using the science themes*, infer* changes in ecosystems prompted by the introduction of new species, environmental conditions, chemicals, and air, water, or earth pollution

Matter, Energy, and Organizaation in Living Systems

F.12.9 Using the science themes*, investigate* energy* systems* (related to food chains) to show* how energy is stored in food (plants and animals) and how energy is released by digestion and metabolism

F.12.10 Understand* the impact of energy* on organisms in living systems*

F.12.11 Investigate* how the complexity and organization* of organisms accommodates the need for obtaining, transforming, transporting, releasing, and eliminating the matter and energy* used to sustain an organism

The Behavior of Organisms

F.12.12 Trace how the sensory and nervous systems* of various organisms react to the internal and external environment and transmit survival or learning stimuli to cause changes in behavior or responses

G. SCIENCE APPLICATIONS

CONTENT STANDARD

Students in Wisconsin will demonstrate an understanding of the relationship between science and technology and the ways in which that relationship influences human activities.

Rationale: Science and technology compliment each other. Science helps drive technology and technology provides science with tools for investigation, inquiry, and analysis. Together, science and technology applications provide solutions to human problems, needs, and aspirations. Students should understand that advances in science and technology affect the earth's systems.

PERFORMANCE STANDARDS

BY THE END OF GRADE 4 STUDENTS WILL:

G.4.1 Identify* the technology used by someone employed in a job or position in Wisconsin and explain* how the technology helps

G.4.2 Discover* what changes in technology have occurred in a career chosen by a parent, grandparent, or an adult friend over a long period of time

G.4.3 Determine what science discoveries have led to changes in technologies that are being used in the workplace by someone employed locally

G.4.4 Identify* the combinations of simple machines in a device used in the home, the workplace, or elsewhere in the community

G.4.5 Ask questions to find answers about how devices and machines were invented and produced

*Terms with an asterisk are defined in the Glossary of Terms.

BY THE END OF GRADE 8 STUDENTS WILL:

G.8.1 Identify* and investigate* the skills people need for a career in science or technology and identify the academic courses that a person pursuing such a career would need

G.8.2 Explain* how current scientific and technological discoveries have an influence on the work people do and how some of these discoveries also lead to new careers

G.8.3 Illustrate* the impact that science and technology have had, both good and bad, on careers, systems, society, environment, and quality of life

G.8.4 Propose a design (or re-design) of an applied science model or a machine that will have an impact in the community or elsewhere in the world and show* how the design (or re-design) might work, including potential side-effects

G.8.5 Investigate* a specific local problem to which there has been a scientific or technological solution, including proposals for alternative courses of action, the choices that were made, reasons for the choices, any new problems created, and subsequent community satisfaction

G.8.6 Use current texts, encyclopedias, source books, computers, experts, the popular press, or other relevant sources to identify* examples of how scientific discoveries have resulted in new technology

G.8.7 Show* evidence* of how science and technology are interdependent, using some examples drawn from personally conducted investigations*

BY THE END OF GRADE 12 STUDENTS WILL:

G.12.1 Identify* personal interests in science and technology; account for implications that these interests might have for future education, and options to be considered

G.12.2 Design, build, evaluate, and revise models* and explanations related to the earth and space, life and environmental, and physical sciences

G.12.3 Analyze* the costs, benefits, or problems resulting from a scientific or technological innovation, including implications for the individual and the community

G.12.4 Show* how a major scientific or technological change has had an impact on work, leisure, or the home

G.12.5 Choose a specific problem in our society, identify* alternative scientific or technological solutions to that problem and argue its merits

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H. SCIENCE IN SOCIAL AND PERSONAL PERSPECTIVES

CONTENT STANDARD

Students in Wisconsin will use scientific information and skills to make decisions about themselves, Wisconsin, and the world in which they live.

Rationale: An important purpose of science education is to give students a means to understand and act on personal, economic, social, political, and international issues. Knowledge and methodology of the earth and space, life and environmental, and physical sciences facilitate analysis of topics related to personal health, environment, and management of resources, and help evaluate the merits of alternative courses of action.

PERFORMANCE STANDARDS

BY THE END OF GRADE 4 STUDENTS WILL:

H.4.1 Describe* how science and technology have helped, and in some cases hindered, progress in providing better food, more rapid information, quicker and safer transportation, and more effective health care

H.4.2 Using the science themes*, identify* local and state issues that are helped by science and technology and explain* how science and technology can also cause a problem

H.4.3 Show* how science has contributed to meeting personal needs, including hygiene, nutrition, exercise, safety, and health care

H.4.4 Develop* a list of issues that citizens must make decisions about and describe* a strategy for becoming informed about the science behind these issues

*Terms with an asterisk are defined in the Glossary of Terms.

BY THE END OF GRADE 8 STUDENTS WILL:

H.8.1 Evaluate* the scientific evidence* used in various media (for example, television, radio, Internet, popular press, and scientific journals) to address a social issue, using criteria of accuracy, logic, bias, relevance of data, and credibility of sources

H.8.2 Present a scientific solution to a problem involving the earth and space, life and environmental, or physical sciences and participate in a consensus-building discussion to arrive at a group decision

H.8.3 Understand* the consequences of decisions affecting personal health and safety

BY THE END OF GRADE 12 STUDENTS WILL:

H.12.1 Using the science themes* and knowledge of the earth and space, life and environmental, and physical sciences, analyze* the costs, risks, benefits, and consequences of a proposal concerning resource management in the community and determine the potential impact of the proposal on life in the community and the region

H.12.2 Evaluate* proposed policy recommendations (local, state, and/or national) in science and technology for validity, evidence, reasoning, and implications, both short and long term

H.12.3 Show* how policy decisions in science depend on many factors, including social values, ethics, beliefs, time-frames, and considerations of science and technology

H.12.4 Advocate a solution or combination of solutions to a problem in science or technology

H.12.5 Investigate* how current plans or proposals concerning resource management, scientific knowledge, or technological development will have an impact on the environment, ecology, and quality of life in a community or region

H.12.6 Evaluate* data and sources of information when using scientific information to make decisions

H.12.7 When making decisions, construct a plan that includes the use of current scientific knowledge and scientific reasoning

Sample Proficiency Standard

SCIENCE

A: SCIENCE CONNECTIONS

CONTENT STANDARD

Students in Wisconsin will understand that among the science disciplines, there are unifying themes: systems, order, organization, and interactions; evidence, models, and explanations; constancy, change, and measurement; evolution, equilibrium, and energy; and form and function.

PERFORMANCE STANDARD

A.8.6: Use models* and explanations* to predict* actions and events in the natural world.

SCIENCE

C: SCIENCE INQUIRY

CONTENT STANDARD

Students in Wisconsin will investigate problems using scientific methods and tools, revise their personal understandings to accommodate knowledge, and communicate these understandings to others.

PERFORMANCE STANDARD

C.8.3: Design and safely conduct investigations* that provide reliable quantitative or qualitative data, as appropriate, to answer their questions.

D. PHYSICAL SCIENCE

CONTENT STANDARD

Students in Wisconsin will demonstrate an understanding of the physical and chemical properties of matter, the forms and properties of energy, and the ways in which matter and energy interact.

PERFORMANCE STANDARD

Transfer of Energy; D.8.9: Explain* the behaviors of various forms of energy* by using models of energy transmission, both in the laboratory and in real-life situations in the outside world.

*Terms with an asterisk are defined in the Glossary of Terms.

SAMPLE TASK

Students were asked to perform the experiment and answer questions about it.

HOT STUFF! is an assessment task in which the students work in small groups in a lab setting to conduct the experiment. The paper and pencil responses to the questions are completed by each individual student and reflect his/her understanding of the experiment.

Purpose

In this inquiry work, you will investigate properties of water and heat transfer and apply the knowledge you have gained from your experiment to real-world problems.

Materials

5 zinc washers with string attached
thermometer
balance
styrofoam cup
hot plate
boiling water
room temperature water

Procedure

1. Carefully find the mass of the zinc washers and string given to you by your teacher. Record the mass in the preliminary data section at the bottom of this page.
2. Place the washers in a boiling water bath.
3. Predict the initial temperature of the washers after sitting for five minutes in the boiling water. Record the prediction in the preliminary data section.
4. Find the mass of a styrofoam cup. Add the mass of tap water that is equal to the mass of the washers and pour it into the Styrofoam cup. Record the mass of the water in the preliminary data section.
5. Measure the temperature of the water in the styrofoam cup and record it in the preliminary data section.
6. Measure the temperature of the water in the hot water bath. Record the temperature of the water bath in the preliminary data section.

Preliminary Data Section

_____ washer mass (g)

_____ water mass (g)

_____ water temp. of hot water bath

_____ predicted temp. of both water and washers

_____ predicted water temp. °C

_____ initial water temp. °C

Follow all your teacher's safety guidelines for this lab!

SAMPLES OF STUDENT WORK

EXPLANATIONS OF RATINGS OF STUDENT WORK

The following criteria were used to evaluate the student work. They were shared with the students before they attempted the task. They were designed to help the student understand the knowledge, skills, concepts, and presentation that was used for the assessment.

The criteria included: *knowledge* (understanding of heat transfer, transfer of knowledge to real-world situations, and use of analogies); *inquiry or use of science skills* (mechanical completeness, accuracy of mathematics and data, presentation of data, use of science terms, and predictions); and *presentation* (material that is understandable to others, use of vocabulary, and use of language such as spelling, etc.).

Advanced

This student clearly has an advanced understanding of this investigation and shows this by using prior knowledge. The chart is well organized. The vocabulary use is exceptional. There are several arguments for the real-world presentations, based on the student's own data. The paper is well written and is clearly understood by the reader. The student accounts for the prediction being different than the experimental results.

7. Suppose the washers are taken out of the boiling water and placed into the water in the Styrofoam cup. They are then allowed to sit until both the washers and the water reach the same temperature. Predict what this final temperature of both the water and th washers will be. Record your prediction in the preliminary data section on the previous page.

Explain your reasons for predicting this temperature.

The washers will give off as much heat as it can until the water temperature equals the washer temperature. I predict that it will reach this equilibrium at 45°C. The washers would give off about half of its total amount and the water will not completely double its temperature. It will come a few degrees short of doubling its temperature.

8. With safety in mind, carefully transfer the steel washers from the hot water into the Styrofoam cup of water.

9. Take the temperature of the water in the Styrofoam cup every 15 seconds. Record the temperatures in the data section. Continue the temperature recording until the temperature reaches a maximum.

Data Section

Time (sec)	Temp (°C)
0	24°
15	27
30	29
45	29
60	31
75	31
90	31
105	31
120	31

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Calculate the temperature change of the water and the temperature change of the metal.

CALCULATIONS

Metal: 85 - 31 = a decrease of 54°

Water: 24 → 31 = an increase of 7°

Explain the differences in the two temperature changes you just calculated.

I can think of two reasons for the differences in the two temperatures. The first considers the conductivity of each part. Metal is a better conductor of heat energy than water. Therefore, the metal washers transfer the heat faster than the water. This explains the larger change of temperature in the metal than in the water. The second reason deals with the volume of the water. If the volume of the water is larger than the volume of the metal then the result will be a smaller change in temperature in the water.

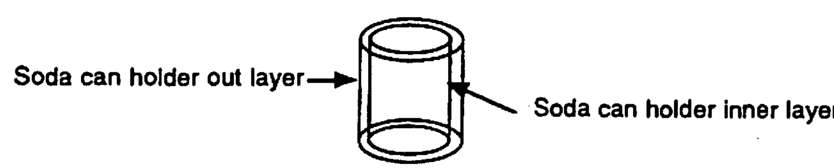
The city of Milwaukee is located on the Lake Michigan shore, while Madison is located 80 miles inland. On a sunny day in July the 2 p.m. temperature in Milwaukee was 82°F; in Madison the temperature was 95°F.

How can this be explained in terms of your experimental results?

The sun is compareable to the metal in the experiment. The sun is giving off its heat energy. Water temperature is lower than the air temperature. In Milwaukee the sun's energy is being absorbed by the water. In Madison the energy is being used to heat the land. Because the initial temp. of the water is less than the temp of the air around Madison its final temp. is less. Just as if in our experiment the initial temp. of the water in the styrofoam cup was lower than the final temperature after the metal was placed would be lower.

A student is designing the perfect soda can holder, which will keep the soda cold. The holder is made of two plastic layers with a space in-between. Refer to the diagram below.

Should the student fill the space with solid steel or an <u>equal mass</u> of water?



Explain in terms of your experimental results.

The student should fill the space with an equal mass of water. Metal is a better conductor of heat than water so the heat from the sun will warm the water. As the heat is transferred the temperature of the can will drop. The same as the metal washers and the result was a drop in the temperature of the washers. The water will also continue to keep the can cold. In the experiment the metal decreased alot and the water increased some but then they remained at that equilibrium. The water and the can would also remain at an equilibrium point. Filling the space with an equal mass of water is the best choice. Water is not as good of a conductor as metal. The water will not transfer the cold from the can. Steel would because it is a better conductor of thermal energy.

Proficient

The paper is complete and accurate. It shows a clear understanding of the experiment. There is good use of scientific terminology and a clear indication of an understanding of heat transfer. The student applies the results of the experiment to the real-world problems successfully.

7. Suppose the washers are taken out of the boiling water and placed into the water in the Styrofoam cup. They are then allowed to sit until both the washers and the water reach the same temperature. Predict what this final temperature of both the water and the washers will be. Record your prediction in the preliminary data section on the previous page.

Explain your reasons for predicting this temperature.

The reasons for predicting the temperature at about 75 degrees is because I chose a number that was a little warmer that the number in between the room temperature water and my hypothesis on the temperature of the heated washers. I think the warmer object will have a bigger impact on the final temp of both the washers + water together.

8. With safety in mind, carefully transfer the steel washers from the hot water into the Styrofoam cup of water.

9. Take the temperature of the water in the Styrofoam cup every 15 seconds. Record the temperatures in the data section. Continue the temperature recording until the temperature reaches a maximum.

Data Section

Time	Temp
Beginning Temp	24°
0	28°
15	29°
30	30°
45	31°
60	31°
75	31°

Calculate the temperature change of the water and the temperature change of the metal.

CALCULATIONS	
Temperature Change in the H_2O	Change (in temp) in the H_2O
$31°C$ $-24°C$ $7°$	$42°C$ — predicted $-31°C$ $11°C$
☆ It had a 7°C temp change.	☆ It had a 11°C temp change.

Explain the differences in the two temperature changes you just calculated.

The differances between the temperatures above is the differance in the water temperature that actually happened. The change on the right side was a prediction or hypothesis. The left colomn is actual + the right column is predicted so everyone's will be differant on the right side + mostly the same on the left. The hot metal causes the room temp. water to go up 30°. The cooler water also helps the metal to cool down to about 30°.

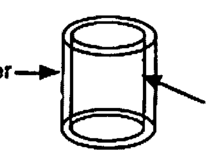
The city of Milwaukee is located on the Lake Michigan shore, while Madison is located 80 miles inland. On a sunny day in July the 2 p.m. temperature in Milwaukee was 82°F; in Madison the temperature was 95°F.

How can this be explained in terms of your experimental results?

Because Milwaukee is closer to the lake shore, the water makes the summers a little bit cooler that the city that is more inland. The city that is inland has no other way to cool down in the summer. Like our experiment explains, the hot metal would be the 2 cities, and the water is the lake. The metal cools down when it is near the cooler water. If the metal were not in water, it would take much longer to cool down.

A student is designing the perfect soda can holder, which will keep the soda cold. The holder is made of two plastic layers with a space in-between. Refer to the diagram below.

Should the student fill the space with solid steel or an equal mass of water?



Explain in terms of your experimental results.

Water → It changes temp more slowly than metal. If you use water, it will keep the soda colder for a longer amount of time than the metal would.

Basic

The student has partially used the science terminology correctly. He or she has presented the investigation in a manner that indicates partial understanding of the concepts of heat transfer. The paper shows limited transfer of the results from the experiment to the real-world problems.

7. Suppose the washers are taken out of the boiling water and placed into the water in the Styrofoam cup. They are then allowed to sit until both the washers and the water reach the same temperature. Predict what this final temperature of both the water and the washers will be. Record your prediction in the preliminary data section on the previous page.

Explain your reasons for predicting this temperature.

The washers will give off as much heat as it can until both have an equal temperature. I don't think that the temp will be that high from the initial temp. of the water. Finally, I think the temp will go up.

8. With safety in mind, carefully transfer the steel washers from the hot water into the Styrofoam cup of water.

9. Take the temperature of the water in the Styrofoam cup every 15 seconds. Record the temperatures in the data section. Continue the temperature recording until the temperature reaches a maximum.

Data Section

time (sec)	Temp.
0	24
.5	27
3.0	29
4.5	29
6.0	31
7.5	31
9.0	31
1.05	31
1.20	31

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Calculate the temperature change of the water and the temperature change of the metal.

CALCULATIONS

Metal 95-31: 64°C

Water - 31-24 = 7°c change

Explain the differences in the two temperature changes you just calculated.

The temperature of the metal was off the furthest because the temp of the water was high and the temp of the water didn't go up real high. The temp of the water was close because the heat from the metal add a little bit of heat to the water.

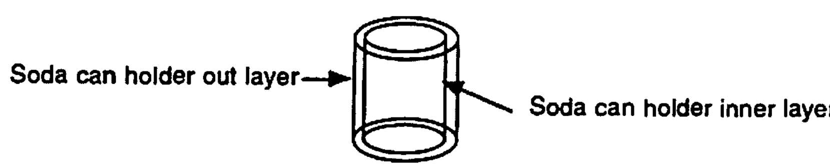
The city of Milwaukee is located on the Lake Michigan shore, while Madison is located 80 miles inland. On a sunny day in July the 2 p.m. temperature in Milwaukee was 82°F; in Madison the temperature was 95°F.

How can this be explained in terms of your experimental results?

Whenever you move towards a lake the temperature is more cooler. This is because the temperature of the water in the lake makes the temp close by the lake cooler. The farther you are away its going to be warmer because you are not close to the lake.

A student is designing the perfect soda can holder, which will keep the soda cold. The holder is made of two plastic layers with a space in-between. Refer to the diagram below.

Should the student fill the space with solid steel or an <u>equal mass</u> of water?



Explain in terms of your experimental results.

The student should fill the space with solid steel. I think if the student does it will keep the coldness in the holder better. The solid steel would be a better insulator for the water. This is why I think that the student should fill the empty space with steel.

Minimal

The paper indicates that the student attempted the investigation. The work presented is only partially accurate. The calculations are difficult to follow and the work was set up incorrectly, but there were answers. The answers were short and incomplete

7. Suppose the washers are taken out of the boiling water and placed into the water in the Styrofoam cup. They are then allowed to sit until both the washers and the water reach the same temperature. Predict what this final temperature of both the water and the washers will be. Record your prediction in the preliminary data section on the previous page.

Explain your reasons for predicting this temperature.

My idea is the Tempratate will reache a happy.

8. With safety in mind, carefully transfer the steel washers from the hot water into the Styrofoam cup of water.

9. Take the temperature of the water in the Styrofoam cup every 15 seconds. Record the temperatures in the data section. Continue the temperature recording until the temperature reaches a maximum.

Data Section

time in 15sec. Intervals	temp.
1	28
2	28
3	28
4	28
5	28
6	28.5
7	29
8	29
9	29
10	29
11	30
12	30
13	30
14	30
15	30

Calculate the temperature change of the water and the temperature change of the metal.

CALCULATIONS

23.5 to 30 = 6.5 Change

Assumed Washers = 100° C - 30°C = 70°C Final
final temp — temp change

Explain the differences in the two temperature changes you just calculated.

The differences in the temperature are larger then each other. So we make the assumetion that water com absorb more heat than metal

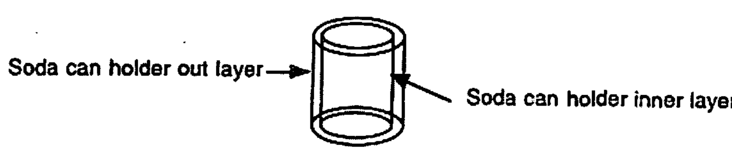
The city of Milwaukee is located on the Lake Michigan shore, while Madison is located 80 miles inland. On a sunny day in July the 2 p.m. temperature in Milwaukee was 82°F; in Madison the temperature was 95°F.

How can this be explained in terms of your experimental results?

Water absorbs more heat than does the other objects

A student is designing the perfect soda can holder, which will keep the soda cold. The holder is made of two plastic layers with a space in-between. Refer to the diagram below.

Should the student fill the space with solid steel or an <u>equal mass</u> of water?



Explain in terms of your experimental results.

Steele - it wont obsorb as much heat as the water would

Glossary of Terms

Science Themes

Each of the following terms refers to a theme that connects and unifies the many disciplines of science. The themes are found particularly in Standard A and are mentioned consistently throughout the science standards. They are identified with an asterisk (*) each time they appear.

Change. A variance in the rate, scale, and pattern, including trends and cycles.

Constancy. The stability of a property, such as the speed of light.

Equilibrium. The physical state in which forces and changes occur in opposite and off-setting directions.

Evidence. Data and documentation that support inferences or conclusions.

Evolution. A series of changes, some gradual and some sporadic, that accounts for the present form and function* of objects.

Explanation. The skill of communication in which an interpretation of information is given and stated to others.

Form and Function. Complimentary aspects of objects, organisms, and systems in the natural world.

Measurement. The quantification of changes in systems, including mathematics.

Models. Tentative schemes or structures that correspond to real objects, events, or classes of events, and that have explanatory power.

Order. The behavior of units of matter, objects, organisms, or events in the universe.

Organization. Descriptions of systems based on complexity and/or order.

Systems. An organized group of related objects or components that form a whole.

Terms Unique to Science

The following terms are used uniquely in science. They are used consistently throughout the standards and are identified by an asterisk (*) each time they appear. They represent the range of rigorous science skills and knowledge found in the standards.

Analyze. The skill of recognizing the underlying details of important facts or patterns that are not always readily visible.

Apply. The skill of selecting and using information in other situations or problems.

Construct. The skill of developing or creating.

Describe. The skill of developing a detailed picture or image.

Discover. The skill of learning through study or investigation.

Energy. The work that a physical system is capable of completing or doing.

Evaluate. The skill of collecting and examining data to make judgments and appraisals.

Group. The skill of identifying objects according to characteristics.

Identify. The skill of recognizing patterns, facts, or details.

Inference. The skill of using the results of an investigation based on a premise.

Illustrate. The skill of giving examples to describe something.

Interaction. The influence of objects, materials, or events on one another.

Investigate. Scientific methodology that systematically employs many inquiry skills.

Observation. The skill of describing scientific events.

Predict. The skill of explaining new events based on observations or information.

Relate. The skill of association.

Show. The skill of illustration.

Understand. The skill of having and applying well-organized bodies of knowledge.

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Appendix

The following people contributed to the development of these Wisconsin Academic Standards in Science by serving as a reviewer and/or a member of a focus group. Their contributions are gratefully acknowledged.

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