Appendix A. Content Framework Summary Documents

This appendix presents information about the NAEP 2000 and TIMSS 2003 science content frameworks used for item classifications at the expert panel meeting.

Exhibit A-1 is the summary document that was used by the expert panel for the classification of items to the *fields of science*, *major topics*, *subtopics*, and *specific objectives* in the NAEP 2000 science framework.

Exhibit A-2 is the summary document that was used by the expert panel for the classification of items to the *content domains*, *topic areas*, and *objectives* in the TIMSS 2003 science framework.

These summary documents are based on the NAEP 2000 and TIMSS 2003 framework and assessment specifications documents, but have been reformatted and adapted slightly to facilitate the classification process.

Exhibit A-1. NAEP science framework and specifications summary: 2000

LIFE SCIENCE (LS)				
A	**Change and evolution**	**Grade(s)**		
A1:	Diversity of life on earth (variations between taxons)	4	8	12
A2:	Genetic variation within a species	(4)	8	12
A3:	Theories of adaptation, including structure-function, and natural selection	(4)	8	12
A4:	Changes in diversity over time (evolution)	•	•	12
B	**Cells and their functions**			
B1:	Cells as systems	•	8	12
B2:	Information transfer in cells	•	•	12
B3:	Energy transfer for the construction of proteins	•	•	12
B4:	Communication among cells	•	•	12
C	**Organisms**			
C1:	Reproduction, growth and development	4	8	12
C2:	Life cycles	4	8	12
C3:	Functions and interactions of systems within organisms	4	8	12
D	**Ecology**			
D1:	The interdependence of life: populations, communities, and ecosystems	4	8	12

See notes at end of exhibit.

Exhibit A-1. NAEP science framework and specifications summary: 2000—Continued

LIFE SCIENCE (LS)		
A Change and evolution		
A1 Diversity of life on earth (variations between taxons)		**4 8 12**
Grade 4	**Grade 8**	**Grade 12**
A1a: Using common (not scientific) names, identify/classify common plants and animals into the major taxonomic groups (e.g., mammal, bird, seed plant) based on their physical characteristics. A1b: Associate the physical appearance of a living thing with the environment it lives in.	A1a: Classify common plants and animals into both the major taxonomic groups [tested at fourth grade] and finer taxonomic groups. A1b: Associate the physical appearance of a living thing with the environment it lives in. A1c: Relate associations of plants and animals with habitats.	A1a: Recognize, classify, or enumerate key characteristics of major groups of animals and plants, e.g., algae, fungi, mammals, arthropods, mosses, etc., and explain their importance or know some significant information that pertains to them. A1b: Arrange the animal and plant phyla in the order in which they are thought to have evolved, e.g., worms prior to insects, reptiles prior to birds.
A2 Genetic variation within a species		**(4) 8 12**
Grade 4	**Grade 8**	**Grade 12**
A2a: Describe/identify random differences between individuals of the same kind of plant or animal. A2b: Recognize the males, females, and young of common species. A2c: Describe/identify similarities and differences between multiple offspring of same parents, and between parents and offspring.	A2a: Describe/identify random differences between individuals of the same kind of plant or animal. A2b: Demonstrate an introductory knowledge of the genetic basis for variation within a species.	A2a: Explain some of the mechanisms of genetic variation. A2b: Discuss ethical issues related to genetic variation in humans.
A3 Theories of adaptation, including structure-function, and natural selection		**(4) 8 12**
Grade 4	**Grade 8**	**Grade 12**
A3a: Identify major body structures of some common organisms. A3b: Relate the structure of body parts, as well as the overall shape of an organism, to function.	A3a: Demonstrate awareness that adaptation may be to either the living or nonliving components of the environment. A3b: Demonstrate awareness that members of a population that survive long enough to reproduce may differ in some ways from members that do not survive to reproductive age, and that their offspring may inherit the anatomical, chemical, and/or behavioral characteristics that enabled the parents to reach reproductive age. A3c: Identify natural selection as the process by which organisms with characteristics that allow them to survive to reproductive age become better represented in future generations. A3d: Identify both adaptation and natural selection as processes which, operating over very long periods of time, have resulted in the diversity of plant and animal life present today.	A3a: Identify, describe, and distinguish among mechanisms of evolution, i.e., adaptation, natural and artificial selection, transfer of genetic material through generations, and the appearance of new traits in individuals and through changes in genetic material (recombination and mutation). A3b: Identify factors such as the isolation of populations, the increase in genetic diversity, and the loss of the ability to interbreed and explain how they cause new species to arise.

See notes at end of exhibit.

Exhibit A-1. NAEP science framework and specifications summary: 2000—Continued

LIFE SCIENCE (LS)		
A Change and evolution		
A4 Changes in diversity over time (evolution) · · **12**		
Grade 4 Not to be tested at this grade level.	**Grade 8** Not to be tested at this grade level.	**Grade 12** A4a: Describe patterns of evolution and consequences of evolution, e.g., adaptation and radiation, and identify evidence for evolution. A4b: Distinguish and explain the principal methods of evolution, e.g., sexual isolation, adaptation, artificial selection, mutation.
B Cells and their functions		
B1 Cells (8) / Cells as systems (12) · **8** **12**		
Grade 4 Not to be tested at this grade level.	**Grade 8** B1a: Describe observations of cells under the microscope. B1b: Explain, in a general way, the advantages of cellular interdependence vs. independence (multicellular animals vs. single-celled animals). B1c: Describe, in general terms, the difference between asexual and sexual reproduction in cells and the advantages and disadvantages of each. [*The stages of mitosis are not to be tested.*]	**Grade 12** B1a: Demonstrate an understanding of the cell as a living system, including the physical structure and chemical activities of the cell.
B2 Information transfer in cells · · **12**		
Grade 4 Not to be tested at this grade level.	**Grade 8** Not to be tested at this grade level.	**Grade 12** B2a: Explain, in general terms, the role DNA plays in controlling cell functions. (CU; S) B2b: Describe/identify examples of the role DNA plays in cell reproduction. (CU; S)
B3 Energy transfer for the construction of proteins · · **12**		
Grade 4 Not to be tested at this grade level.	**Grade 8** Not to be tested at this grade level.	**Grade 12** B3a: Describe the transformations of matter and energy during photosynthesis and cellular respiration, and explain how cells use food for growth.
B4 Communication among cells · · **12**		
Grade 4 Not to be tested at this grade level.	**Grade 8** Not to be tested at this grade level.	**Grade 12** B4a: Demonstrate an understanding of the roles of specialized cells in carrying out life functions, e.g., respiration, digestion, immune protection, nervous and hormonal control. B4b: Explain how cells communicate. Offer or identify several examples of intercellular communication, i.e., that what goes on in one cell may affect many.

See notes at end of exhibit.

Exhibit A-1. NAEP science framework and specifications summary: 2000—Continued

LIFE SCIENCE (LS)		
C Organisms		
C1 Reproduction, growth and development	**4**	**8**	**12**
Grade 4	**Grade 8**	**Grade 12**
C1a: Identify/explain that only adults can reproduce and that not all young live to adulthood. C1b: Identify examples (of species or larger taxons) of animals that produce hundreds of eggs or young, and animals that produce few or only a single offspring at any given time. C1c: Identify reproductive structures of plants and animals.	C1a: Describe growth, development, and reproduction of the human organism.	C1a: Demonstrate knowledge that a cell is the fundamental unit of a living organism. C1b: Demonstrate an understanding of the growth of multicellular organisms by cell growth and reproduction, i.e., mitosis (asexual) and meiosis (sexual) with corresponding transfer of one-half of DNA information from each parent.
C2 Life cycles	**4**	**8**	**12**
Grade 4	**Grade 8**	**Grade 12**
C2a: Describe life cycles, including growth and metamorphosis, of familiar organisms.	C2a: Identify some major influences on the human life cycle, such as diet and disease.	C2a: Describe the life cycles of representative organisms that cause human diseases. C2b: Describe the use of technology in the prevention, diagnosis, and treatment of disease. C2c: Discuss ethical issues related to disease and disease prevention, such as: What is the relationship between hunger and disease? If the world could eliminate hunger, what might be the consequences?
C3 Functions and interactions of systems within organisms	**4**	**8**	**12**
Grade 4	**Grade 8**	**Grade 12**
C3a: Identify major internal systems of both plants and animals and associate them with their functions. C3b: Demonstrate an introductory knowledge of interdependence of body systems, i.e., when something happens in one part of the body, it affects what goes on in other parts of the body. C3c: Describe/identify the relationship between the structure of a body part and its function.	C3a: Demonstrate awareness that while different systems of the body have different functions, the functioning of each system affects other systems, e.g., describe/identify major organ systems of the human body, state their major functions, and describe some of their interactions. C3b: Demonstrate an understanding of the functions and interactions of organ systems to maintain a stable internal environment that can resist disturbance from within or without (homeostasis).	C3a: Describe/identify major organ systems of the human body, state their major functions, and describe some of their interactions. C3b: Demonstrate an understanding of the functions and interactions of organ systems to maintain a stable internal environment that can resist disturbance from within or without (homeostasis). C3c: Answer questions about health issues based on knowledge of body systems and functions. C3d: Discuss ethical issues related to health and physical well-being.

See notes at end of exhibit.

Exhibit A-1. NAEP science framework and specifications summary: 2000—Continued

LIFE SCIENCE (LS)		
D Ecology		
D1 The interdependence of life: populations, communities, and ecosystems	**4**	**8** **12**
Grade 4	**Grade 8**	**Grade 12**
D1a: Demonstrate introductory knowledge of photosynthesis, i.e., that green plants make their own food with sunlight, water and air (also under C 3). D1b: Describe basic requirements for living things, e.g., plants and animals need food for energy and growth. D1c: Describe positive and negative effects of human beings on the environment.	D1a: Describe the flow of energy in ecosystems, i.e., identify plants as the source of food energy for all animals, describe the process by which plants use energy in sunlight to assemble food molecules from water and carbon dioxide, and describe the processes by which plants and animals break down food molecules to obtain food energy. D1b: Demonstrate an understanding of the patterns of relationships among populations and the effects of changes in one population in a food web on another, including the environmental effects of human activity. D1c: Design systems that encourage growth of certain plants and animals.	D1a: Describe the complexity of ecosystems, i.e., how interactions between living and nonliving components of an ecosystem affect the functioning of that system as a whole and how ecosystems respond to natural and human changes in the environment (ecological succession). D1b: Make predictions about changes in the size or growth rate of a population using mathematical models. D1c: Describe matter cycles and energy flow (nutrient cycles) in ecosystems. D1d: Describe/predict how human activity impacts nutrient cycles in ecosystems, e.g., impact of building a dam on a selected ecosystem.

See notes at end of exhibit.

Exhibit A-1. NAEP science framework and specifications summary: 2000—Continued

PHYSICAL SCIENCE (PS)				
A	**Matter and its transformations**	**Grade(s)**		
A1:	Diversity of matter (materials): classification and types, particulate nature of matter, conservation of matter	4	8	12
A2:	Temperature and states of matter (physical changes)	4	8	12
A3:	Properties and uses of materials: modifying properties, synthesis of materials with new properties	4	8	12
A4:	Resource management	•	•	12
B	**Energy and its transformations**			
B1:	Forms of energy	4	8	12
B2:	Energy transformations in living systems, natural physical systems, and artificial systems constructed by humans	4	8	12
B3:	Energy sources and use, including distribution, conversion, costs, and depletion	4	8	12
C	**Motion**			
C1:	Frames of reference	4	8	12
C2:	Force and motion	4	8	12
C3:	Action and reaction	•	8	12
C4:	Vibrations and waves as motion (includes sound)	4	8	12
C5:	General wave behavior	•	•	12
C6:	Electromagnetic radiation, including its interactions with matter	4	8	12

See notes at end of exhibit.

Exhibit A-1. NAEP science framework and specifications summary: 2000—Continued

PHYSICAL SCIENCE (PS)

A Matter and its transformations

A1 Diversity of matter (materials): classification and types, particulate nature of matter, conservation of matter — 4 8 12

Grade 4	Grade 8	Grade 12
A1a: Classify/identify common objects and substances by physical characteristics such as a state of matter, texture, color, size, shape, hardness, and opacity. A1b: Use metric devices to measure linear dimensions of objects, weight, volume, temperature. A1c: Demonstrate understanding that changing the shape or physical state of an object does not change in weight (mass) of the object.	A1a: Know that matter is composed of extremely small particles (atoms). Demonstrate awareness that atoms combine to form molecules and complex structures. [Factual information about the infrastructure of the atom is not to be tested]. A1b: Classify substances as elements, compounds, or mixtures. A1c: Describe/demonstrate how mixtures can be separated into their component parts, e.g., boiling, filtering, screening, use of tweezers, magnets, etc. A1d: Demonstrate an understanding of conservation of matter. A1e: Make appropriate measurements in situations requiring distinctions between mass and volume for liquids and gases and between linear dimensions and volume of solids.	A1a: Distinguish/classify objects, both regular and irregular; pure substances, both elements and compounds; and mixtures, both homogeneous (solutions, liquids, and gases) and nonhomogeneous. A1b: Describe, measure, and compare substances in terms of mass, volume, and density/specific gravity. A1c: Identify evidence that matter is composed of tiny particles (atoms, molecules), and that the particles are in motion (kinetic molecular theory). A1d: Define, describe, and contrast physical, chemical, and nuclear changes in molecular terms. A1e: Discuss the conservation of matter in physical, chemical, and nuclear changes. [*Can also be tested under temperature states of matter, or energy and its transformations*]

A2 Temperature and states of matter (physical changes) — 4 8 12

Grade 4	Grade 8	Grade 12
A2a: Identify/describe freezing, melting, boiling, evaporation, and condensation and the resulting changes in size and appearance of common substances, e.g., water/ice, wax, butter, sugar, etc.	A2a: Discuss changes in the physical state of matter (solid, liquid, gaseous) in terms of the arrangement and motion of molecules and how these changes are related to temperature. A2b: Explain other common physical changes, such as dissolving and thermal expansion, in molecular terms. A2c: Identify/distinguish between chemical and physical changes in natural and technological systems and describe those changes in molecular terms.	A2a: Discuss/identify the relation of physical states of matter to molecular energy. A2b: Discuss/identify the relation of physical changes in substances (i.e., melting, boiling, thermal expansion and contraction, compression and expansion under pressure, increase or decrease in density) to changes in the structural organization of the atoms or molecules of which they are composed.

See notes at end of exhibit.

Exhibit A-1. NAEP science framework and specifications summary: 2000—Continued

PHYSICAL SCIENCE (PS)		
A Matter and its transformations		
A3 Properties and uses of materials: modifying properties, synthesis of materials with new properties 4 8 12		
Grade 4	**Grade 8**	**Grade 12**
A3a: Identify useful properties of common materials. A3b: Sort/classify materials by useful properties such as magnetism, and conductivity, density, solubility. A3c: Describe the properties of magnets.	A3a: Explain that all diverse substances that are found or made are arrangements of a small number of pure elements. A3b: Examine useful properties of materials, e.g., density, solubility, acidity, etc. A3c: Select/suggest appropriate uses of combinations of materials, considering their properties, e.g., alloys.	A3a: Relate the physical properties (e.g., compressibility, structural rigidity) of pure substances in solid, liquid, and gaseous states to the structural organization of particles in the substance and their freedom of motion. A3b: Examine/Utilize useful properties of materials. A3c: Describe how common artificial materials are made, recognizing that substances can be designed to have certain properties, and that the addition of relatively small amounts of some substances can significantly alter the properties. A3d: Describe how common artificial materials are disposed of or recycled and discuss the technological and environmental issues involved in these processes.
A4 Resource management • • 12		
Grade 4	**Grade 8**	**Grade 12**
Not to be tested at this grade level.	Not to be tested at this grade level.	A4a: Discuss scientific, technological, environmental, and social issues involved in resource management.
B Energy and its transformations		
B1 Forms of energy 4 8 12		
Grade 4	**Grade 8**	**Grade 12**
B1a: Explain that energy appears in various forms, and that each form of energy has its own characteristics. B1b: Explain that heat is a form of energy often produced as a byproduct when one form of energy is converted to another form, and that reducing the amount of heat produced saves energy. B1c: Explain how any change in a system can be traced to the addition, transformation, or subtraction of energy from the system.	B1a: Describe common forms of energy (e.g., light, heat, sound, kinetic, potential, food) found familiar systems. B1b: Recognize the relationship between magnetism and electricity. Demonstrate awareness that magnetism can produce electricity and that electricity can produce magnetism.	B1a: In addition to the energy forms (heat, light, sound, motion, food) tested at eighth grade, identify/explain/describe the electromagnetic, electrical, chemical, mechanical, and nuclear forms of energy. B1b: Relate forms of energy with common uses of those energy forms in daily living.

See notes at end of exhibit.

Exhibit A-1. NAEP science framework and specifications summary: 2000—Continued

PHYSICAL SCIENCE (PS)		
B Energy and its transformations		
B2 Energy transformations in living systems, natural physical systems, and artificial systems constructed by humans **4 8 12**		
Grade 4	**Grade 8**	**Grade 12**
B2a: Explain that energy is required when work is done on a system or when matter changes its form. B2b: Understand that energy transfer is essential to all living organisms. B2c: Identify common energy changes, e.g., a light bulb converts electricity into heat and light, a golf club converts human energy into the motion of the club and golf ball, etc.	B2a: Describe common energy transformations found in familiar systems, both technological and natural. B2b: Demonstrate an understanding of total energy conservation when energy conversion takes place.	B2a: Explain/describe energy transformations in natural and technological systems. B2b: Explain the relationship, in energy transformations, between loss of input energy as heat and lowered efficiency of the transformation. B2c: Demonstrate both qualitative and quantitative understanding of the conversation of energy in physical and chemical changes.
B3 Energy sources and use, including distribution, conversion, costs, and depletion **4 8 12**		
Grade 4	**Grade 8**	**Grade 12**
B3a: Demonstrate awareness that the Sun is the ultimate source of most energy we use. B3b: Explain that energy is used to do mechanical work and identify examples. B3c: Explain the difference between renewable and nonrenewable resources. B3d: Describe a variety of ways that people use energy. B3e: Describe/list a variety of ways that energy can be stored, e.g., springs, batteries, body fat, plants.	B3a: Discuss that energy conversions used in technology may produce undesirable side effects on the surroundings that should be minimized. B3b: Describe/identify limits on our abilities to conserve energy resources and recognize renewable and nonrenewable resources. B3c: Demonstrate awareness that balancing energy requirements in a technological society with resource limits also requires balancing scientific, technical, political, economic, and social factors.	B3a: Describe specific chemical changes in the formation and use of fossil fuels.

See notes at end of exhibit.

Exhibit A-1. NAEP science framework and specifications summary: 2000—Continued

PHYSICAL SCIENCE (PS)

C Motion

C1 Frames of reference — 4 8 12

Grade 4	Grade 8	Grade 12
C1a: Demonstrate an understanding that everything moves. C1b: Demonstrate awareness that positions of things may be described in reference to something else. C1c: Demonstrate awareness that positions change (motion), and that monitoring changes of position in time yields information about speed. [*Should be tested only qualitatively and in familiar contexts, such as running races*] C1d: Describe and compare motions of common objects in terms of speed and direction. [*Should be tested only qualitatively and in familiar contexts*]	C1a: Demonstrate awareness that everything is moving, and that descriptions of motion depend on the frame of reference being used, i.e., are relative to whatever point, object, or path is defined. C1b: Demonstrate qualitative and quantitative understanding of speed and velocity, i.e., relate speed to time and distance. C1c: Demonstrate awareness of the kinds of motion that are characterized by both speed and direction (velocity).	C1a: Demonstrate awareness that everything is moving, and that descriptions of motion depend on the frame of reference being used. C1b: Isolate one component of a complex system and describe the motion of that component relative to the system as a whole. C1c: Represent and analyze motion both quantitatively and graphically.

C2 Force and motion — 4 8 12

Grade 4	Grade 8	Grade 12
C2a: Relate changes in motion to the effects of forces, including gravitational force.	C2a: Describe balanced and unbalanced forces and explain their impact on an object's state of motion, including state of rest. C2b: Describe qualitatively the relationship between the net force exerted on a body and the resultant acceleration due to the force. C2c: Identify frictional forces and describe their impact on motion. C2d: Define/Describe momentum.	C2a: Demonstrate both qualitative and quantitative understanding of the relationship between the net force exerted on a body and the resultant acceleration due to the force (including gravitational). C2b: Demonstrate both qualitative and quantitative understanding of momentum.

C3 Action and reaction — • 8 12

Grade 4	Grade 8	Grade 12
Not to be tested at this grade level.	C3a: Understand and give examples (colliding cars, billiard balls, swinging pendulum) of the principle that when X exerts a force on Y, Y exerts an equal force on X in the opposite direction.	C3a: Demonstrate qualitative and quantitative understanding of pressure. C3b: Demonstrate qualitative understanding of the principle of equal and opposite forces.

See notes at end of exhibit.

Exhibit A-1. NAEP science framework and specifications summary: 2000—Continued

PHYSICAL SCIENCE (PS)		
C Motion		
C4 Vibrations and waves as motion (includes sound)		**4 8 12**
Grade 4	**Grade 8**	**Grade 12**
C4a: Identify some common vibrations and waves and describe their motion. C4b: Explain that vibrations may set up a traveling disturbance (wave) that spreads away from its source.	C4a: Recognize that vibrations move through systems as waves. C4b: Describe vibration in terms of frequency and amplitude. C4c: Relate characteristics of sounds, i.e., loudness and pitch, to amplitude and frequency. C4d: Describe/demonstrate how sound travels through different materials, i.e., how sound is transmitted, reflected, and absorbed. C4e: Describe the motions of pendulums and other vibrating objects.	C4a: Explain how apparent changes in wavelength provide information about relative motion. C4b: Identify the properties of sound, i.e., intensity, frequency, and harmonic content, and relate them to the effects, i.e., loudness, pitch, and quality. C4c: Explain how echoes occur.
C5 General wave behavior		**• • 12**
Grade 4	**Grade 8**	**Grade 12**
Not to be tested at this grade level.	Not to be tested at this grade level.	C5a: Describe wave behavior in terms of speed, wavelength, and frequency. [*Can also be tested under vibrations and waves as motion*] C5b: Describe the relationship between wavelength and how well a wave is transmitted, absorbed, reflected, or diffracted. [*Can also be tested under electromagnetic radiation, below*] C5c: Explain how media affect the motion of waves.
C6 Electromagnetic radiation, including its interactions with matter		**4 8 12**
Grade 4	**Grade 8**	**Grade 12**
C6a: Describe basic properties of light, e.g., brightness and colors. C6b: Explain how light illuminates objects and how it causes them to cast shadows. C6c: Explain that things appear to have different colors because they reflect or scatter light of some colors more than others.	C6a: Cite evidence of the wave properties of light, i.e., changing direction, bouncing off surfaces, spreading out, speeding up, slowing down, changing wavelength. C6b: Explain how objects are seen, i.e., light is reflected from them to the eye. C6c: Show awareness of electromagnetic spectrum, especially the visible region. C6d: Understand that objects and media reflect, transmit, or absorb light. C6e: Understand that lenses bend (refract) light to magnify, reduce, and/or project images.	C6a: Demonstrate an understanding of electromagnetic waves, i.e., the electromagnetic spectrum. C6b: Describe the interaction of electromagnetic radiation with matter, i.e., that matter reflects, transmits, or absorbs light.

See notes at end of exhibit.

Exhibit A-1. NAEP science framework and specifications summary: 2000—Continued

EARTH SCIENCE (ES)				
A	**Solid Earth (lithosphere)**	**Grade(s)**		
A1:	Composition of the Earth	4	8	12
A2:	Forces that alter the Earth's surface	4	8	12
A3:	Rocks: their formation, characteristics and uses	4	8	12
A4:	Soil: its changes and uses	4	8	12
A5:	Resources from the Earth used by humankind	4	8	12
A6:	Forces within the Earth	•	8	12
B	**Water (hydrosphere)**			
B1:	The water cycle	4	8	12
B2:	Nature of the oceans and their effects	4	8	12
B3:	The location of water, its distribution, characteristics, effect of and influence on human activity	4	8	12
C	**Air (atmosphere)**			
C1:	The composition and structure of the atmosphere, including energy transfer	•	8	12
C2:	The nature of weather	4	8	12
C3:	Climate	•	8	12
C4:	Interactions of human society with atmosphere	4	8	12
D	**Earth in Space**			
D1:	The setting of the Earth in the solar system	4	8	12
D2:	The setting and evolution of the solar system in the universe	•	8	12
D3:	Tools and technology that are used to gather information about space	4	8	12
D4:	The tilt of the Earth's axis, its rotation about its axis, and its revolution around the Sun	4	8	12
D5:	Earth history: Includes the ideas that the Earth is a unique member of our solar system; it may be approximated in other star systems and galaxies in the universe; and that it evolved at least 4.5 billion years ago.	(4)	8	12

See notes at end of exhibit.

Exhibit A-1. NAEP science framework and specifications summary: 2000—Continued

EARTH SCIENCE (ES)		
A Solid Earth (lithosphere)		
A1 Composition of Earth		**4 8 12**
Grade 4	**Grade 8**	**Grade 12**
A1a: Classify substances as soil, sand or rock. A1b: Identify common geographic features of landscapes.	A1a: Identify some elements and minerals that are abundant in the Earth's crust. A1b: Know that the interior of the Earth is hot and is composed of two major volumes: the mantle and the core. A1c: Understand that the components of the solid Earth undergo transformations over very long periods of time. A1d: Know that the solid Earth is composed of a finite number of elements.	A1a: Describe the interior composition of the Earth, including its core, mantle, and crust. A1b: Explain how scientists use seismographic evidence in determining the structure and composition of the Earth's interior.
A2 Forces that alter the Earth's surface		**4 8 12**
Grade 4	**Grade 8**	**Grade 12**
A2a: Describe/identify/explain basic facts about major features of the Earth's surface and natural changes in those features, e.g., volcanoes, glaciers.	A2a: Use maps to identify surface features of the Earth. A2b: Demonstrate an understanding of the ways that gravity, forces in the interior of the Earth, weather, water, plants, animals, and civilizations impact the Earth's features. [*Can also be tested under rocks, below.*]	A2a: Use maps to identify surface features of the Earth. A2b: Demonstrate understanding of ways that gravity, forces in the interior of the Earth, weather, water, plants, animals, and civilizations impact the Earth's features.
A3 Rocks: their formation, characteristics and uses		**4 8 12**
Grade 4	**Grade 8**	**Grade 12**
A3a: Identify common rocks and minerals and explain how we can investigate what they are made of and how they form.	A3a: Demonstrate an understanding of geologic and climatic changes over time (e.g., formation of rocks, minerals and fossils) and their use in explaining the age of the Earth. A3b: Describe characteristics of common rocks.	A3a: Understand rock cycles. A3b: Discuss the uses of knowledge about rock cycles.
A4 Soil: its changes and uses		**4 8 12**
Grade 4	**Grade 8**	**Grade 12**
A4a: Know some facts about the composition of soil. A4b: Recognize that plants grow in soil and that the soil provides both nutrients and support for plants.	A4a: Know that soils are typed by the relative proportions of inorganic and organic components. A4b: Identify common soil conservation methods.	A4a: Trace the factors in soil formation from lava to mature productive soils. A4b: Discuss problems associated with agriculture and lithosphere.

See notes at end of exhibit.

Exhibit A-1. NAEP science framework and specifications summary: 2000—Continued

EARTH SCIENCE (ES)		
A Solid Earth (lithosphere)		
A5 Resources from the Earth used by humankind		**4 8 12**
Grade 4	**Grade 8**	**Grade 12**
A5a: Identify Earth resources used in everyday life. A5b: Explain/identify that some Earth resources must be processed to make them useful.	A5a: Identify Earth materials that people use and where to find them. A5b: Identify how and where we get energy from the Earth. A5c: Describe the reasons for using and not using (conserving) the Earth's resources.	A5a: Identify Earth materials that people use and where to find them. A5b: Identify how and where we get energy from the Earth. A5c: Discuss issues related to the effects of human activity on Earth systems, including the importance of conservation and recycling, the limits of the Earth's natural resources, and the impact of technology on the use of these resources.
A6 Forces within the Earth		**• 8 12**
Grade 4	**Grade 8**	**Grade 12**
Not to be tested at this grade level.	A6a: Describe how earthquake occurrences are recorded and note some positional regularities, e.g., locate earthquake belts of the Earth. A6b: Describe the effect of volcanic activity on short-term climate changes. A6c: Demonstrate/explain how to use a compass and explain how its workings are related to the Earth's magnetic field.	A6a: Describe the interior of the Earth. A6b: Identify/explain the effect of the movement of crustal plates that are moving apart, that are moving together, and that are scraping against each other on the continental landforms (moving apart: sea floor spreading; moving together: mountain building and subduction; scraping against: earthquakes). A6c: Discuss continental drift.
B Water (hydrosphere)		
B1 The water cycle		**4 8 12**
Grade 4	**Grade 8**	**Grade 12**
B1a: Describe the water cycle. Describe how water enters and leaves the atmosphere and explain the flow of water after precipitation.	B1a: Relate common interactive cycles such as the water cycle (flow of water after precipitation), the nitrogen cycle, and the carbon cycle.	B1a: Discuss how water or the lack of it influences climates. B1b: Describe the energy that drives the water cycle. B1c: Describe the natural and manmade events that may change the water cycle, and the effects that these changes may have on society.
B2 Nature of the oceans and their effects		**4 8 12**
Grade 4	**Grade 8**	**Grade 12**
B2a: Know that most of the Earth's surface is covered by water. B2b: Locate the Atlantic and Pacific Oceans on a map or globe. B2c: Identify salt as the major difference between fresh and ocean waters. B2d: Describe some of the effects of oceans on climate.	B2a: Identify the correct ratio between the area of the Earth's surface that is covered by oceans and the area that is dry land. B2b: Describe the motions of ocean waters and identify their causes. B2c: Identify/explain the effects of oceans on climate.	B2a: Identify/describe resources provided by the oceans (food, minerals, recreation, transportation). B2b: Identify/describe the effects of the oceans on global climates. B2c: Identify/describe the effects of human activity on the oceans (waste dumps, oil spills, global warming).

See notes at end of exhibit.

Exhibit A-1. NAEP science framework and specifications summary: 2000—Continued

EARTH SCIENCE (ES)		
B Water (hydrosphere)		
B3 The location of water, its distribution, characteristics, effect of and influence on human activity **4 8 12**		
Grade 4	**Grade 8**	**Grade 12**
B3a: Know that water exists not only on the Earth's surface but beneath the Earth's surface as well. B3b: Understand that water exists in three physical states on Earth. *[Can also be tested under water cycle, above]* B3c: Identify land features that are shaped by water and design simple models to illustrate the action of water in shaping the Earth's surface. *[Can also be tested under forces that alter the Earth's surface, above]* B3d: Identify common sources of water and explain/describe people's dependence on water for daily activities. B3e: List some ways we can use water more wisely.	B3a: Demonstrate awareness that water is found in the air, on the surface of the Earth, and under the ground. B3b: Describe the three physical states of water on Earth and the conditions under which they exist. *[Can also be tested under Physical Science]* B3c: Describe physical characteristics of lakes, oceans, and rivers and their relation to habitats for plant and animal life. [*Can also be tested under Life Science*.] B3d: Describe what properties make water special. B3e: Discuss some common problems related to water, e.g., availability, purity, relationship to supply and demand, effects of overpopulation on availability, and quality of water. B3f: Describe ways scientists explore the water environment.	B3a: Trace the movement of water in the air, on the surface of the Earth, and under the ground. B3b: Describe the three physical states of water on Earth, conditions under which they exist, and their uses. *[Can also be tested under Physical Science]* B3c: Describe physical characteristics of lakes, oceans, and rivers and their relation to habitats for plant and animal life. *[Can also be tested under Life Science]* B3d: Discuss some common problems that concern water, e.g., availability, purity, relationship to supply and demand, effects of overpopulation on availability and quality of water. B3e: Describe ways scientists explore the water environment.
C Air (atmosphere)		
C1 The composition and structure of the atmosphere, including energy transfer **• 8 12**		
Grade 4	**Grade 8**	**Grade 12**
Not to be tested at this grade level.	C1a: Describe/identify the composition and physical characteristics of the atmosphere. C1b: Describe the structure of the Earth's atmosphere.	C1a: Know that the chemical balance of the atmosphere is maintained by cycles. C1b: Identify/describe levels or layers of the atmosphere. C1c: Discuss energy transfer in the atmosphere.

See notes at end of exhibit.

Exhibit A-1. NAEP science framework and specifications summary: 2000—Continued

EARTH SCIENCE (ES)		
C Air (atmosphere)		
C2 The nature of weather		**4 8 12**
Grade 4	**Grade 8**	**Grade 12**
C2a: Describe the different phenomena of weather conditions, such as clouds, temperature, and types of precipitation. C2b: Explain the relationship of seasonal changes to weather conditions. C2c: Describe weather changes, list ways of measuring them, and offer simple explanations for how the weather changes. C2d: Use and make weather charts and temperature measurements.	C2a: Describe/identify interactions of water and the Sun's heat energy in cycles of precipitation and evaporation. C2b: Explain weather-related phenomena such as thunderstorms, tornados, hurricanes, cyclones, drought, or acid precipitation. C2c: Describe/explain patterns of changing weather. C2d: Describe/use weather measurement methods such as charts, barometers, or anemometers.	C2a: Describe patterns of circulation of air around the planet and explain how they affect weather conditions. C2b: Explain and predict general weather patterns, based on knowledge of phenomena that determine weather.
C3 Climate		**• 8 12**
Grade 4	**Grade 8**	**Grade 12**
Not to be tested at this grade level.	C3a: Define climate as the long-term average weather of a region and describe/explain climates of major Earth regions. C3b: Demonstrate an understanding of how relatively small changes in global temperatures can have dramatic effects on the Earth's climate.	C3a: Identify major climatic zones of the world (polar, middle latitude, and tropical) and identify relationships of weather conditions to these zones. C3b: Explain changes in climate over long periods of time, i.e., atmospheric phenomena and long-term effects. C3c: Explain how scientists monitor atmospheric events over time.
C4 Interactions of human society with atmosphere		**4 8 12**
Grade 4	**Grade 8**	**Grade 12**
C4a: Describe ways human beings protect themselves from adverse weather conditions. C4b: Identify/explain some effects human activities have on weather.	C4a: Describe ways human beings protect themselves from adverse weather conditions. C4b: Identify/explain/discuss some effects human activities have on weather and atmosphere.	C4a: Explain the impact of human activities on the atmosphere, demonstrating knowledge of the products of air pollution. C4b: Discuss the causes of air pollution and possible solutions in relation to their consequences and tradeoffs.

See notes at end of exhibit.

Exhibit A-1. NAEP science framework and specifications summary: 2000—Continued

EARTH SCIENCE (ES)		
D Earth in Space		
D1 The setting of the Earth in the solar system	**4**	**8** **12**
Grade 4	**Grade 8**	**Grade 12**
D1a: Explain how the Earth differs from the Sun and the Moon. D1b: Explain how the Earth relates to the Sun: periodicity, seasons, night and day. *[May also be tested under tilt of the Earth, below]*	D1a: Describe the location and motion of the Earth and its Moon in the solar system. D1b: Identify the other planets in the solar system and describe their motions, as well as the motions of moons and comets. D1c: Describe the characteristics of Earth and other planets in the solar system in terms of their abilities to support life. *[Can also be tested under Earth history]*	D1a: Describe the energy that reaches Earth from the Sun, identify the process by which the Sun generates its energy, and relate the Sun's energy to its effects on Earth. D1b: Discuss issues related to efficient use of the Sun's energy.
D2 The setting and evolution of the solar system in the universe	**•**	**8** **12**
Grade 4	**Grade 8**	**Grade 12**
Not to be tested at this grade level.	D2a: Describe the current scientific theory of the origin and evolution of the Earth and the solar system. D2b: Know the characteristics of stars (large, hot, energy radiators). D2c: Know that a galaxy is a group of many stars and that the Sun is one of many stars in our galaxy.	D2a: Describe how stars form and how they produce energy. D2b: Demonstrate awareness of the similarity of materials and forces found everywhere in the universe. D2c: Demonstrate awareness of observations/theories of the structure and evolution of the universe.
D3 Tools and technology that are used to gather information about space	**4**	**8** **12**
Grade 4	**Grade 8**	**Grade 12**
D3a: Describe the use of telescopes, satellites, space shuttles, etc., to gather information about space.	D3a: Show familiarity with common instruments used to study objects in space, e.g., telescopes, spectrographs. D3b: In general terms, explain the role of gravity in orbital motion of both natural and man made satellites; i.e., gravitational forces hold objects in orbit around another object; gravity must be overcome in order to achieve or leave orbit; or the Earth is held in place around the Sun by gravitational force. D3c: Describe space explorations and the knowledge gained from them.	D3a: Understand that the majority of the knowledge about the universe is based on analysis of the electromagnetic radiation reaching the Earth. D3b: Discuss "spinoffs" from space exploration that affect daily life.

See notes at end of exhibit.

Exhibit A-1. NAEP science framework and specifications summary: 2000—Continued

EARTH SCIENCE (ES)		
D Earth in Space		
D4 The tilt of the Earth's axis, its rotation about its axis, and its revolution around the Sun	**4**	**8** **12**
Grade 4 D4a: Explain some consequences of the Earth's rotation about its axis. D4b: Explain the relation of seasonal phenomena to the revolution of the Earth, spinning on a tilted axis, around the Sun.	**Grade 8** D4a: Explain phases of the Moon in terms of relative positions of the Earth, Moon, and Sun. D4b: Explain/describe the relation of seasonal phenomena to the revolution of the Earth, spinning on a tilted axis, around the Sun. D4c: Explain how the apparent motions of the stars have been used in navigation. D4d: Explain the association of time measurement with celestial motions.	**Grade 12** D4a: Explain the relationship of the tides to Sun and Moon positions. D4b: Use latitude and longitude in determining locations on the Earth's surface.
D5 Earth history: Includes the ideas that the Earth is a unique member of our solar system; it may be approximated in other star systems and galaxies in the universe; and that it evolved at least 4.5 billion years ago.	**(4)**	**8** **12**
Grade 4 D5a: Identify/cite evidence that the Earth is very old.	**Grade 8** D5a: Identify/cite evidence that the Earth is very old. D5b: Identify phases in the Earth's history, including cooling from a molten state, development of the atmosphere, and the collection of water in liquid phase on the Earth's surface. D5c: Discuss the role of life in the Earth's history.	**Grade 12** D5a: Identify/cite evidence that the Earth is very old. D5b: Identify phases in the Earth's history, including cooling from the molten state, development of the atmosphere, and the collection of water in liquid phase on the Earth's surface.

NOTE: In each *field of science* (life science, physical science, etc.) *major topics* are identified by capital letters (A, B, C,…), *subtopics* are identified by numbers (1, 2, 3,…), and *specific objectives* are identified by lowercase letters (a, b, c,…). Subtopics can be assessed at those grade levels indicated by 4, 8, and 12 on the right side of the table. Parentheses around a grade level indicate that a topic may be introduced at a simple level at that grade. If a subtopic should not be addressed at a specific grade level, it is indicated by a dot (•).

SOURCE: U.S. Department of Education, National Assessment Governing Board, *Science Assessment and Exercise Specifications for the 1994 National Assessment of Educational Progress,* 1994; and U.S. Department of Education, National Assessment Governing Board, *Science Framework for the 1996 and 2000 National Assessment of Educational Progress*, 2000.

Exhibit A-2. TIMSS science framework and specifications summary: 2003

LIFE SCIENCE (LS)		Grade(s)	
1	Types, Characteristics, and Classification of Living Things	4	8
2	Structure, Function, and Life Processes in Organisms	4	8
3	Cells and Their Functions	•	8
4	Development and Life Cycles of Organisms	4	8
5	Reproduction and Heredity	(4)	8
6	Diversity, Adaptation, and Natural Selection	4	8
7	Ecosystems	4	8
8	Human Health	4	8

See notes at end of exhibit.

Exhibit A-2. TIMSS science framework and specifications summary: 2003—Continued

LIFE SCIENCE (LS)			
1 Types, Characteristics, and Classification of Living Things		**4**	**8**
Grade 4	**Grade 8**		
1a: - Explain differences between living and nonliving things based on common features (movement, basic needs for air/food/water, reproduction, growth, response to stimuli). 1b: - Compare and contrast physical and behavioral characteristics of humans and other major groups of organisms (e.g., insects, birds, mammals, plants). - Identify/provide examples of plants and animals belonging to these groups.	1a: - State the defining characteristics that are used to differentiate among the major taxonomic groups and organisms within these groups. - Classify organisms on the basis of a variety of physical and behavioral characteristics.		
2 Structure, Function, and Life Processes in Organisms		**4**	**8**
Grade 4	**Grade 8**		
2a: - Relate major body structures in humans and other organisms (plants and animals) to their functions (e.g., digestion takes place in the stomach, plant roots absorb water, teeth break down food, bones support the body, lungs take in oxygen). 2b: - Demonstrate knowledge of bodily actions in response to outside conditions (e.g., heat, cold, danger) and activities (e.g., exercise).	2a: - Locate major organs in the human body. - Identify the components of organ systems. - Compare/contrast organs and organ systems in humans and other organisms. 2b: - Relate the structure and function of organs and organ systems to the basic biological processes required to sustain life (sensory, digestive, skeletal/muscular, circulatory, nervous, respiratory, reproductive). 2c: - Explain how biological actions in response to specific external/internal changes work to maintain stable bodily conditions (e.g., sweating in heat, shivering in cold, increased heart rate during exercise).		

See notes at end of exhibit.

Exhibit A-2. TIMSS science framework and specifications summary: 2003—Continued

LIFE SCIENCE (LS)	
3 Cells and Their Functions • **8**	
Grade 4	**Grade 8**
Not Assessed.	3a: - Describe the cellular make-up of all living organisms (both single-celled and multi-cellular). - Demonstrate knowledge that cells carry out life functions and undergo cell division during growth/repair in organisms. - Demonstrate knowledge that tissues, organs, and organ systems are formed from groups of cells with specialized structures and functions. 3b: - Identify cell structures and some functions of cell organelles (cell wall, cell membrane, nucleus, cytoplasm, chloroplast, mitochondria, vacuoles), including a comparison of plant and animal cells. 3c: - Provide a general description of the process of photosynthesis that takes place in plant cells (the need for light, carbon dioxide, water, and chlorophyll, production of food, and release of oxygen). 3d: - Describe the process of respiration that takes place in plant and animal cells (the need for oxygen, breaking down of food to produce energy, and release of carbon dioxide).
4 Development and Life Cycles of Organisms **4** **8**	
Grade 4	**Grade 8**
4a: - Trace the general steps in the life cycle of organisms (birth, growth and development, reproduction, and death). - Know and compare life cycles of familiar organisms (e.g., humans, butterflies, frogs, plants, mosquitoes).	4a: - Compare and contrast how different organisms grow and develop (e.g., humans, plants, birds, insects).
5 Reproduction and Heredity **(4)** **8**	
Grade 4	**Grade 8**
5a: - Recognize that plants and animals reproduce with their same kind to produce offspring with features that closely resemble those of the parents.	5a: - Explain that reproduction (asexual or sexual) occurs in all living organisms and is important for the survival of species. - Compare/contrast biological processes in asexual and sexual reproduction in general terms (e.g., cell division to produce an identical offspring versus combination of egg and sperm from female/male parents to produce offspring that are similar but not identical to either parent). - State advantages and disadvantages of each type of reproduction. 5b: - Relate the inheritance of traits to the passing on of genetic material contained in the cells of the parent(s) to their offspring. - Distinguish inherited characteristics from physical/behavioral features that are acquired/learned.

See notes at end of exhibit.

Exhibit A-2. TIMSS science framework and specifications summary: 2003—Continued

LIFE SCIENCE (LS)		
6 Diversity, Adaptation, and Natural Selection	**4**	**8**
Grade 4		**Grade 8**
6a: - Associate physical features and patterns of behavior of plants and animals with the environments in which they live. - Identify/provide examples of certain physical or behavioral characteristics of plants/animals that make them better suited for survival in different environments and explain why (e.g., camouflage, color change, fur thickness).		6a: - Relate the survival/extinction of different species to variation in physical/behavioral characteristics in a population and reproductive success in changing environments. 6b: - Demonstrate knowledge of the relative time major groups of organisms have existed on the earth (e.g., humans, reptiles, fish, plants). - Describe how similarities and differences among living species and fossils provide evidence of the changes that occur in living things over time.
7 Ecosystems	**4**	**8**
Grade 4		**Grade 8**
7a: - Explain that all plants and animals need food to provide fuel for activity and material for growth and repair. - Understand that plants need the sun to make their own food, while animals consume plants and/or other animals as food. 7b: - Explain relationships in a given community (e.g., forest, tidepool) based on simple food chains, using common plants and animals and predator/prey relationships. *[Assessment objectives related to the effects of human behavior on environments are described in the Environmental Science section.]*		7a: - Demonstrate knowledge of the flow of energy in an ecosystem (the role of photosynthesis and respiration and the storage of food/energy products in organisms). - Identify different organisms as producers, consumers, and decomposers. - Draw/interpret food pyramids or food web diagrams. 7b: - Describe the role of organisms in the cycling of materials through the earth's surface (e.g., oxygen/carbon dioxide, water) and the decomposition of organisms and recycling of elements back into the environment. 7c: - Discuss the interdependence of populations of organisms in an ecosystem in terms of the effects of competition and predation. - Identify factors that can limit population size (e.g., disease, predators, food resources, drought). - Predict effects of changes in an ecosystem (e.g., climate, water, supply, food supply, population changes, migration) on the available resources and the balance among populations.

See notes at end of exhibit.

Exhibit A-2. TIMSS science framework and specifications summary: 2003—Continued

LIFE SCIENCE (LS)	
8 Human Health	**4 8**
Grade 4	**Grade 8**
8a: - Recognize ways that common communicable diseases (e.g., colds, influenza) are transmitted. - Identify signs of health/illness and some methods of preventing and treating illness. 8b: - Describe ways of maintaining good health, including the need for a balanced/varied diet, identification of common food sources (e.g., fruits and vegetables, grains), and the effect of personal habits on health (e.g., using sunscreen, preventing injury, personal hygiene, exercise, drug, alcohol, and tobacco use).	8a: - Describe causes of common infectious diseases, methods of infection/transmission, prevention, and the importance of the body's natural resistance (immunity) and healing capabilities. 8b: - Explain the importance of diet, hygiene, exercise, and lifestyle in maintaining health and preventing illness (e.g., heart disease, diabetes, skin cancer, lung cancer). - Identify the dietary sources and role of nutrients in a healthy diet (vitamins, minerals, proteins, carbohydrates, fats).

See notes at end of exhibit.

Exhibit A-2. TIMSS science framework and specifications summary: 2003—Continued

CHEMISTRY (CH)		Grade(s)	
1	Classification and Composition of Matter	4	8
2	Particulate Structure of Matter	•	8
3	Properties and Uses of Water	(4)	8
4	Acids and Bases	•	8
5	Chemical Change	(4)	8

See notes at end of exhibit.

Exhibit A-2. TIMSS science framework and specifications summary: 2003—Continued

CHEMISTRY (CH)	
1 Classification and Composition of Matter	**4 8**
Grade 4	**Grade 8**
1a: - Compare/classify/order different objects and materials on the basis of observable physical properties (e.g., weight/mass, shape, volume, color, hardness, texture, odor, taste, magnetic attraction). 1b: - Identify some properties of metals and relate them to their use (e.g., conduct heat and electricity, are hard, are shiny, can be molded). 1c: - Identify/describe mixtures on the basis of physical appearance. - Demonstrate understanding that mixtures can be separated based on the observable properties of their parts (e.g., particle size, shape, color, magnetic attraction). 1d: - Give examples of some materials that will dissolve in water and some that will not. - Identify common conditions that increase the amount of material that will dissolve or the speed at which materials dissolve (hot water, stirring, small particles).	1a: - Classify/compare substances on the basis of characteristic physical properties that can be demonstrated or measured (e.g., density, thermal/electrical conductivity, solubility, melting/boiling point, magnetic properties). 1b: - Recognize that substances may be grouped according to similar chemical and physical properties. - Describe properties of metals that distinguish them from other common substances (nonmetals). 1c: - Differentiate between pure substances (elements and compounds) and mixtures (homogeneous and heterogeneous) on the basis of their formation and composition, and provide/identify examples of each (solid, liquid, gas). 1d: - Select/describe physical methods for separating mixtures into their components (e.g., filtration, distillation, sedimentation, magnetic separation, flotation, dissolution). 1e: - Define solutions in terms of substance(s) (solid, liquid, or gas solutes) dissolved in a solvent. - Apply knowledge of the relationship between concentration/dilution and the amounts of solute/solvent and the effect of factors such as temperature, stirring, and particle size.
2 Particulate Structure of Matter	**• 8**
Grade 4	**Grade 8**
Not Assessed.	2a: - Describe the structure of matter in terms of particles, including molecules as combinations of atoms and atoms as being composed of subatomic particles (electrons surrounding a nucleus containing protons and neutrons).
3 Properties and Uses of Water	**(4) 8**
Grade 4	**Grade 8**
3a: - Identify common uses of water in each of its forms (e.g., solvent, coolant, heat source).	3a: - Identify water as a compound with molecules composed of one oxygen atom and two hydrogen atoms. - Relate the behavior/uses of water to its physical properties (e.g., melting point and boiling point, ability to dissolve many substances, thermal properties, expansion upon freezing).

See notes at end of exhibit.

Exhibit A-2. TIMSS science framework and specifications summary: 2003—Continued

CHEMISTRY (CH)	
4 Acids and Bases	**• 8**
Grade 4	**Grade 8**
Not Assessed.	4a: - Compare the properties and uses of common acids and bases (acids have a sour taste and react with metals; bases usually have a bitter taste and slippery feel; strong acids and bases are corrosive; both acids and bases dissolve in water and react with indicators to produce different color changes; acids and bases neutralize each other).
5 Chemical Change	**(4) 8**
Grade 4	**Grade 8**
5a: - Identify some familiar changes in materials that produce other materials with different characteristics (e.g., decaying of animal/plant matter, burning, rusting, cooking).	5a: - Differentiate chemical from physical changes in terms of the transformation (reaction) of one or more substances (reactants) into different substances (products). - Provide evidence that a chemical change has taken place based on common examples (e.g., temperature change, gas production, color change, light emission). 5b: - Recognize that although matter changes form during chemical change, its total amount is conserved. 5c: - Recognize the need for oxygen in common oxidation reactions (combustion, rusting). - Compare the relative tendency of familiar substances to undergo these reactions (e.g., combustion of gasoline versus water, corrosion of steel versus aluminum). 5d: - Demonstrate understanding that some chemical reactions give off while others absorb heat/energy. - Classify familiar chemical transformations as either releasing or absorbing heat/energy (e.g., burning, neutralization, cooking).

See notes at end of exhibit.

Exhibit A-2. TIMSS science framework and specifications summary: 2003—Continued

PHYSICS (PH)		Grade(s)	
1	Physical States and Changes in Matter	4	8
2	Energy Types, Sources and Conversions	(4)	8
3	Heat and Temperature	4	8
4	Light	4	8
5	Sound and Vibration	•	8
6	Electricity and Magnetism	4	8
7	Forces and Motion	4	8

See notes at end of exhibit.

Exhibit A-2. TIMSS science framework and specifications summary: 2003—Continued

PHYSICS (PH)	
1 Physical States and Changes in Matter	**4 8**
Grade 4	**Grade 8**
1a: - Describe that all objects/materials are made up of matter that exists in three major states (solid, liquid, gas). - Describe differences in the observable physical properties of solids, liquids, and gases in terms of shape and volume. 1b: - Demonstrate knowledge that water exists in different physical states and can be changed from one state to another by heating or cooling, and describe these changes in familiar terms (melting, freezing, boiling).	1a: - Use knowledge about the movement of and distance between particles to explain differences in the physical properties of solids, liquids, and gases (volume, shape, density, compressibility). 1b: - Describe the processes of melting, freezing, evaporation, and condensation as changes of state resulting from the supplying or removing of heat/energy. - Relate the rate/extent of these processes to common physical factors (surface area, dissolved substances, temperature, altitude/pressure). 1c: - Demonstrate understanding of the melting/boiling point of substances. - Explain why temperature remains constant during phase change (melting, boiling, freezing). 1d: - Illustrate understanding that matter (mass) is conserved during familiar physical changes (e.g., change of state, dissolving solids, thermal expansion).
2 Energy Types, Sources and Conversions	**(4) 8**
Grade 4	**Grade 8**
2a: - Identify common energy sources and forms (e.g., wind, sun, electricity, burning fuel, water wheel, food). - Know some practical uses of energy.	2a: - Identify different forms of energy (e.g., mechanical, light, sound, electrical, thermal, chemical). - Describe simple energy transformations (e.g., combustion in an engine to move a car, electrical energy to power a lamp, hydroelectric power, changes between potential and kinetic energy). - Apply knowledge of the concept of conservation of total energy.
3 Heat and Temperature	**4 8**
Grade 4	**Grade 8**
3a: - Demonstrate knowledge that heat flows from a hot object to a cold object and causes materials to change temperature and volume. - Identify common materials that conduct heat better than others. - Recognize the relationship between temperature measurements and how hot/cold an object is.	3a: - Relate heat to the transfer of energy from an object at a high temperature to one at a lower temperature. - Compare the relative thermal conductivity of different materials. - Compare/contrast methods of heat transfer (conduction, convection, and radiation). 3b: - Explain thermal expansion in terms of change in volume and/or pressure (e.g., thermometers, balloons). 3c: - Relate temperature and changes in volume and/or pressure to the movement/speed of particles.

See notes at end of exhibit.

Exhibit A-2. TIMSS science framework and specifications summary: 2003—Continued

PHYSICS (PH)		
4 Light		**4 8**
Grade 4	**Grade 8**	
4a: - Identify common sources of light (e.g., bulb, flame, sun). - Relate familiar physical phenomena to the presence/absence and behavior of light (e.g., appearance of rainbows; colors produced from prisms, oil slicks, soap bubbles, etc.; formation of shadows; visibility of objects; mirrors).	4a: - Describe/identify some basic properties/behaviors of light (transmission from a source through different media; speed of light compared to sound; reflection, refraction (bending), absorption, and transmission by different materials; splitting of white light into its component colors by prisms and other dispersive media). 4b: - Relate the appearance/color of objects to the properties of reflected/absorbed light. 4c: - Solve practical problems involving the reflection of light from plane mirrors and the formation of shadows. - Use/interpret ray diagrams to identify the path of light and locate reflected/projected images.	
5 Sound and Vibration		**• 8**
Grade 4	**Grade 8**	
Not Assessed.	5a: - Explain how sound with varying loudness (intensity) and pitch is produced by vibrations with different properties (amplitude, frequency).* - Recognize that sound is transmitted away from a source through different materials and can be reflected by surfaces. ** Knowledge/use of the specific terms amplitude and frequency is not expected at grade 8.*	
6 Electricity and Magnetism		**4 8**
Grade 4	**Grade 8**	
6a: - Know common uses of electricity. - Identify a complete electrical circuit using batteries, bulbs, wires, and other common components that conduct electricity. 6b: - Know that magnets have north and south poles, that like poles repel and opposite poles attract, and that magnets can be used to attract some other materials/objects.	6a: - Describe the flow of current in an electrical circuit. - Draw/identify diagrams representing complete circuits (series and parallel). - Classify materials as electrical conductors or insulators. - Recognize that there is a relationship between current and voltage in a circuit. 6b: - Demonstrate knowledge of the properties of permanent magnets and the effects of magnetic force. - Identify essential features and practical uses of electromagnets.	

See notes at end of exhibit.

Exhibit A-2. TIMSS science framework and specifications summary: 2003—Continued

PHYSICS (PH)	
7 Forces and Motion	**4 8**
Grade 4	**Grade 8**
7a: - Identify familiar forces that cause objects to move (e.g., gravity acting on falling objects, push/pull forces). 7b: - Describe how the relative weight of objects can be determined using a balance. - Relate the weight* of different objects to their ability to float or sink. ** Although buoyancy is a function of density, knowledge of the term and concept of density and the distinction between weight and mass is not expected at grade 4. At this level, students may be assessed on their knowledge of flotation using objects of comparable size but different weight/mass.*	7a: - Represent the motion of an object in terms of its position, direction, and speed in a given reference frame. - Compute speed from time and distance using standard units. - Use/interpret information in distance versus time graphs. 7b: - Describe general types of forces (e.g., weight as a force due to gravity, contact force, buoyant force, friction). - Predict changes in motion (if any) of an object based on the forces acting on it. - Demonstrate basic knowledge of work and the function of simple machines (e.g., levers) using common examples. 7c: - Explain observable physical phenomena in terms of density differences (e.g., floating/sinking objects, rising balloons, ice layers). 7d: - Demonstrate knowledge of effects related to pressure (e.g., atmospheric pressure as a function of altitude, ocean pressure as a function of depth, evidence of gas pressure in balloons, spreading force over a large/small area, fluid levels).

See notes at end of exhibit.

Exhibit A-2. TIMSS science framework and specifications summary: 2003—Continued

EARTH SCIENCE (ES)		Grade(s)	
1	Earth's Structure and Physical Features	4	8
2	Earth's Processes, Cycles, and History	4	8
3	Earth in the Solar System and the Universe	4	8

See notes at end of exhibit.

Exhibit A-2. TIMSS science framework and specifications summary: 2003—Continued

EARTH SCIENCE (ES)	
1 Earth's Structure and Physical Features	**4 8**
Grade 4	**Grade 8**
1a: - Know that the surface of the earth is composed of rocks, minerals, sand, and soil. - Compare physical properties, locations, and uses of these materials. 1b: - Recognize that most of the earth's surface is covered with water. - Describe the locations/types of water found on the earth (e.g., salt water in oceans, fresh water in lakes and rivers, clouds, snow, ice caps, icebergs). 1c: - Provide evidence for the existence/nature of air, including the fact that air contains water (e.g., cloud formation, dew drops, evaporation of ponds), examples of the uses of air, and the importance of air for supporting life. 1d: - Identify/describe common features of the earth's landscape (e.g., mountains, plains, rivers, deserts) and relate them to human use (e.g., farming, irrigation, land development).	1a: - Demonstrate knowledge of the structure and physical characteristics of the earth's crust, mantle, and core. - Use/interpret topographic maps. - Describe the formation, characteristics, and/or uses of soil, minerals, and basic rock types. 1b: - Compare the physical state, movement, composition and relative distribution of water on the earth (e.g., oceans, rivers, ground water, glaciers, ice caps, clouds). 1c: - Know that the earth's atmosphere is a mixture of gases, and identify the relative abundance of its main components. - Relate changes in atmospheric conditions (temperature, pressure, composition) to altitude. [*Assessment objectives related to the use and conservation of earth's natural resources are described in the Environmental Science section.]*

See notes at end of exhibit.

Exhibit A-2. TIMSS science framework and specifications summary: 2003—Continued

EARTH SCIENCE (ES)	
2 Earth's Processes, Cycles, and History	**4 8**
Grade 4	**Grade 8**
2a: - Draw/describe the movement of water on the earth's surface (e.g., flowing in rivers/streams from mountains to oceans/lakes). - Relate the formation of clouds and rain/snow to a change of state of water. 2b: - Describe changes in weather conditions from day to day or over the seasons in terms of observable properties such as temperature, precipitation (rain/snow), clouds, and wind. 2c: - Recognize that fossils of animals and plants that lived on the earth a long time ago can be found in rocks and provide evidence that the earth is very old.	2a: - Demonstrate knowledge of the general processes involved in the rock cycle (weathering/erosion, deposition, heat/pressure, melting/cooling, lava flow) resulting in the continuous formation of igneous, metamorphic, and sedimentary rock. 2b: - Diagram/describe the steps in the earth's water cycle (evaporation, condensation, and precipitation), referencing the sun as the source of energy and the role of cloud movement and water flow in the circulation and renewal of fresh water on the earth's surface. 2c: - Interpret weather data/maps, and relate changing weather patterns to global and local factors in terms of temperature, pressure, precipitation, wind speed/direction, cloud types/formation, and storm fronts. 2d: - Compare seasonal climates of major regions on the earth, considering effects of latitude, altitude and geography (e.g., mountains and oceans). - Identify/describe long- and short-term climatic changes (e.g., ice ages, global warming trends, volcanic eruptions, changes in ocean currents). 2e: - Identify/describe physical processes and major geological events that have occurred over billions of years (e.g., weathering, erosion, deposition, volcanic activity, earthquakes, mountain building, plate movement, continental drift). - Explain the formation of fossils and fossil fuels.

See notes at end of exhibit.

Exhibit A-2. TIMSS science framework and specifications summary: 2003—Continued

EARTH SCIENCE (ES)	
3 Earth in the Solar System and the Universe	**4 8**
Grade 4	**Grade 8**
3a: - Describe the solar system as a group of planets (including earth) each revolving around the sun. - Identify the sun as the source of heat and light for the solar system. 3b: - Relate daily patterns observed on the earth to the earth's rotation on its axis and its relationship to the sun (e.g., day/night, appearance of shadows). 3c: - Draw/describe the phases of the moon.	3a: - Explain phenomena on the earth (day/night, tides, year, phases of the moon, eclipses, seasons in the northern/southern hemisphere, appearance of sun, moon, planets, and constellations) in terms of the relative movements, distances, and sizes of the earth, moon, and other bodies in and outside the solar system. 3b: - Recognize the role of gravity in the solar system (e.g., tides, keeping the planets and moons in orbit, pulling us to the earth's surface). 3c: - Compare and contrast the physical features of the earth with the moon and other planets (e.g., atmosphere, temperature, water, distance from sun, period of revolution/rotation, ability to support life). 3d: - Recognize the sun as an "average" star, and know that there are billions of other stars in the universe outside and very distant from the earth's solar system.

See notes at end of exhibit.

Exhibit A-2. TIMSS science framework and specifications summary: 2003—Continued

ENVIRONMENTAL SCIENCE (EV)	Grade(s)	
1 Changes in Population	•	8
2 Use and Conservation of Natural Resources	4	8
3 Changes in Environments	4	8

See notes at end of exhibit.

Exhibit A-2. TIMSS science framework and specifications summary: 2003—Continued

ENVIRONMENTAL SCIENCE (EV)	
1 Changes in Population	**• 8**
Grade 4	**Grade 8**
Not Assessed.	1a: - Analyze trends in human population, identifying that the world population is growing at an increasing rate, and comparing the population distribution, growth rate, and consumption/availability of resources in different regions. 1b: - Discuss effects of population growth on the environment (e.g., use of natural resources, food supply/demand, health, water supply/demand, growth of cities/suburbs, land use/development, hunting/fishing).
2 Use and Conservation of Natural Resources	**4 8**
Grade 4	**Grade 8**
2a: - Identify some of the earth's physical resources that are used in everyday life and their common sources (e.g., water, soil, wood, minerals, fuel, food). - Explain the importance of using these resources wisely. *Note: Environmental Science is not reported separately at Grade 4. Items measuring understandings related to the use and conservation of natural resources are reported in Life Science or Earth Science.*	2a: - Know common examples of renewable and nonrenewable resources. - Discuss advantages and disadvantages of different types of energy sources (e.g., fossil fuels, wood, solar, wind, geothermal, nuclear, hydroelectric, chemical batteries). - Describe methods of conservation and waste management (e.g., recycling/reuse, use of biodegradable materials). 2b: - Relate effects of human use of land/soil resources (e.g., farming, ranching, mining, tree harvesting) to methods used in agriculture and land management (e.g., crop rotation, terracing/contour farming, fertilization, irrigation, pest control, grazing management, reclamation/recycling, reforesting). 2c: - Discuss factors related to the supply/demand of fresh water and use of water resources (e.g., renewable but limited supply of fresh water, purification, desalination, irrigation, water treatment/reuse, conservation, use of dams, fishing practices).

See notes at end of exhibit.

Exhibit A-2. TIMSS science framework and specifications summary: 2003—Continued

ENVIRONMENTAL SCIENCE (EV)	
3 Changes in Environments	**4 8**
Grade 4	**Grade 8**
3a: - Present ways in which human behavior can have a positive or a negative effect on environments. - Provide general descriptions and examples of the effects of pollution on humans, plants, animals, and their environments, and ways of preventing or reducing pollution. *Note: Environmental Science is not reported separately at grade 4. Items measuring understandings related to changes in environments are reported in Life Science or Earth Science.*	3a: - Discuss ways in which human activity can both contribute to and help solve environmental problems, including both short- and long-term effects on ecosystems. - Describe sources, effects, and ways of preventing/reducing air, water, and land pollution. - Explain the role of science and technology in addressing environmental issues. 3b: - Relate some global environmental concerns to their possible causes and/or effects (e.g., global warming, acid rain, depletion of the ozone layer, deforestation, desertification). - Present ways in which science and technology can be used to address these concerns. 3c: - Describe some natural hazards and their impact on humans, wildlife, and the environment in terms of changes to habitat, resources, food webs, and life cycles (e.g., earthquakes, landslides, wildfires, volcanic eruptions, floods, storms).

NOTE: In each science *content domain* (life science, chemistry, etc.) *topic areas* are identified by numbers (1, 2, 3,…) and *specific objectives* are identified by lowercase letters (a, b, c,…). Topic areas can be assessed at those grade levels indicated by 4 and 8 on the right side of the table. Parentheses around a grade level indicate that a topic area may be introduced at a simple level at that grade. If a topic area should not be addressed at a specific grade level, it is indicated by a dot (•).
SOURCE: International Study Center, Lynch School of Education, Boston College, *TIMSS Assessment Frameworks and Specifications 2003, 2nd Edition*, 2003.

Appendix B. Summary Information on Cognitive Domains and Scientific Inquiry

Exhibit B-1 is the document that was used by the expert panel for the classification of items to the *cognitive domains* in the TIMSS 2003 science framework. Exhibit B-2 is the document that was used for the *scientific inquiry* classifications. Both summary documents are based on the TIMSS 2003 framework but have been reformatted and adapted slightly to facilitate the classification process.

Exhibit B-1. Cognitive domains based on the TIMSS 2003 science framework

Factual Knowledge (FK)	Conceptual Understanding (CU)	Reasoning and Analysis (RA)
Items in the FK category assess students' knowledge base of relevant science facts, information, tools, vocabulary, symbols, units, and procedures.	Items in the CU category assess students' understanding of the relationships that explain the behavior of the physical/natural world and the ability to relate the observable to more abstract or general scientific concepts. Items in this category involve more straightforward applications of concepts and require less analysis and integration than those in the RA category.	Items in the RA category assess students' scientific reasoning and analysis skills used to solve problems; develop, evaluate and justify explanations and problem-solving strategies; draw conclusions; make decisions; and extend knowledge to new situations. Items may involve less familiar or more complicated contexts and require students to bring together knowledge and understanding from different areas.
Specific demands that items in this category might make include: • Recall/Recognize • Define • Describe • Use Tools & Procedures	Specific demands that items in this category might make include: • Illustrate with examples • Compare/contrast/classify • Represent/model • Relate • Extract/apply information • Find solutions • Explain	Specific demands that items in this category might make include: • Analyze/interpret/solve problems • Integrate/synthesize • Hypothesize/predict • Design/plan • Collect/analyze/interpret data • Draw conclusions • Generalize • Evaluate • Justify

See notes at end of exhibit.

Exhibit B-1. Cognitive domains based on the TIMSS 2003 science framework—Continued

Factual Knowledge

Recall/Recognize	• Make or identify accurate statements about science facts, relationships processes, and concepts. • Identify the characteristics or properties of specific organisms, materials, and processes.
Define	• Provide or identify definitions of scientific terms. • Recognize and use scientific vocabulary, symbols, abbreviations, units, and scales in relevant contexts.
Describe	• Recognize or describe organisms, physical materials, and science processes that demonstrate knowledge of properties, structure, function, and relationships.
Use Tools & Procedures	• Demonstrate knowledge of the use of science apparatus, equipment, tools, procedures, and measurement devices/scales.

See notes at end of exhibit.

Exhibit B-1. Cognitive domains based on the TIMSS 2003 science framework—Continued

Conceptual Understanding

Illustrate with Examples	• Support or clarify statements of facts/concepts with appropriate examples. • Identify or provide specific examples to illustrate knowledge of general concepts.
Compare/Contrast/Classify	• Identify or describe similarities and differences between groups of organisms, materials, or processes. • Distinguish, classify or order individual objects, materials, organisms, and processes based on characteristics and properties.
Represent/Model	• Use/draw diagrams and/or models to demonstrate understanding of science concepts, structures, relationships, processes, and biological/physical systems and cycles (*e.g., food webs, electrical circuits, water cycle, solar system, atomic structure*).
Relate	• Relate knowledge of underlying biological and physical concepts to the observed or inferred properties/behaviors/uses of objects, organisms, and materials.
Extract/Apply Information	• Identify/extract/apply relevant textual, tabular, or graphical information in light of science concepts/principles.
Find Solutions	• Identify/use science relationships, equations, and formulas to find qualitative or quantitative solutions involving the direct application/demonstration of concepts.
Explain	• Provide or identify reasons/explanations for observations or natural phenomena, demonstrating understanding of the underlying science concept, principle, law, or theory.

See notes at end of exhibit.

Exhibit B-1. Cognitive domains based on the TIMSS 2003 science framework—Continued

Reasoning and Analysis

Analyze/Interpret/Solve Problems	• Analyze problems to determine the relevant relationships, concepts, and problem-solving steps. • Develop/explain problem-solving strategies. • Interpret/use diagrams and graphics to visualize and/or solve problems. • Give evidence of deductive and inductive reasoning processes used to solve problems.
Integrate/Synthesize	• Provide solutions to problems that require consideration of a number of different factors or related concepts. • Make associations/connections between concepts in different areas of science. • Demonstrate understanding of unified concepts and themes across the domains of science. • Integrate mathematical concepts/procedures in the solutions to science problems.
Hypothesize/Predict	• Combine knowledge of science concepts with information from experience or observation to formulate questions that can be answered by investigation. • Formulate hypotheses as testable assumptions using knowledge from observation and/or analysis of scientific information and conceptual understanding. • Make predictions about the effects of changes in biological or physical conditions in light of evidence and scientific understanding.
Design/Plan	• Design/plan investigations appropriate for answering scientific questions or testing hypotheses. • Describe/recognize the characteristics of well-designed investigations in terms of variables to be measured and controlled and cause-and-effect relationships. • Make decisions about measurements/procedures to use in conducting investigations.
Collect/Analyze/Interpret Data	• Make/record systematic observations and measurements, demonstrating appropriate applications of apparatus, equipment, tools, procedures, and measurement devices/scales. • Represent scientific data in tables, charts, graphs, and diagrams using appropriate format, labeling, and scales. • Select/apply appropriate mathematical computations/techniques to data to obtain derived values necessary to draw conclusions. • Detect patterns in data, describe/summarize data trends, and interpolate/extrapolate from data or given information.
Draw Conclusions	• Make valid inferences on the basis of evidence and/or understanding of science concepts. • Draw appropriate conclusions that address questions/hypotheses and demonstrate understanding of cause and effect.

See notes at end of exhibit.

Exhibit B-1. Cognitive domains based on the TIMSS 2003 science framework—Continued

Reasoning and Analysis—Continued

Generalize	• Make/evaluate general conclusions that go beyond the experimental or given conditions. • Apply conclusions to new situations. • Determine general formulas for expressing physical relationships.
Evaluate	• Weigh advantages and disadvantages to make decisions about alternative processes, materials, and sources. • Consider scientific and social factors to evaluate the impact/consequences of science and technology in biological and physical systems. • Evaluate alternative explanations and problem-solving strategies and solutions. • Evaluate results of investigations with respect to sufficiency of data to support conclusions.
Justify	• Use evidence and scientific understanding to justify explanations and problem solutions. • Construct arguments to support the reasonableness of solutions to problems, conclusions from investigations, or scientific explanations.

SOURCE: International Study Center, Lynch School of Education, Boston College, *TIMSS Assessment Frameworks and Specifications 2003, 2nd Editi*on, 2003.

Exhibit B-2. Scientific inquiry based on the TIMSS 2003 science framework

How is scientific inquiry defined?

- Treated as an overarching dimension that overlaps all the fields of science and has both content- and skills-based components.
- Includes knowledge, skills, and abilities assessed by items or tasks set in different content-related contexts and covering a range of cognitive demands.
- Items/tasks assessing scientific inquiry are associated with both a content and cognitive domain as well as identified as engaging students in knowledge and/or process skills involved in scientific inquiry.

Includes two components:

General knowledge about the nature of science and scientific inquiry:	Knowledge and process skills involved in five major phases of the scientific inquiry process:
• Scientific knowledge is subject to change • Importance of using different methods in verifying/testing knowledge • Use of basic "scientific methods" • Communication of results • Interaction of science, mathematics and technology	• Formulating questions and hypotheses • Designing investigations • Collecting and representing data • Analyzing and interpreting data • Drawing conclusions and developing explanations

Understandings and abilities increase across grades:

Grade 4	Grade 8
• Demonstrate knowledge of a "fair test". • Describe/conduct an investigation. • Make systematic observations or measurements using simple tools, equipment, and procedures. • Represent findings using simple charts and diagrams. • Apply routine mathematical computations of measured values. • Identify simple relationships. • Briefly describe results of investigations. • State simple conclusions from investigations to answer a specific question.	• Formulate hypotheses or predictions based on observation or scientific knowledge that can be tested. • Specify variables to be controlled and varied in well-designed investigations. • Make decisions about measurements, equipment and procedures. • Collect/represent data using appropriate terminology, units, precision, format, and scales. • Analyze data using appropriate mathematical techniques. • Describe patterns in data. • Demonstrate understanding of cause and effect. • Draw conclusions based on evidence and in light of scientific understanding. • Evaluate results of investigations, including sufficiency of data for supporting conclusions. • Consider alternative explanations • Apply/extend conclusions to new situations.

SOURCE: International Study Center, Lynch School of Education, Boston College, *TIMSS Assessment Frameworks and Specifications 2003, 2nd Edition*, 2003.

Appendix C. Expert Panel

Members and Staff

Expert Panel Members

Alicia Cristina Alonzo
California Institute of Technology

Rodger W. Bybee
Biological Sciences Curriculum Study (BSCS)

Audrey B. Champagne
University at Albany
State University of New York

W. Tony Heiting
Iowa Department of Education

Tricia R. Kerr
The Ohio State University

Gregory Kirchhofer
Columbia Public Schools (MO)

Mary Lauko
Educational Testing Service

Brett D. Moulding
Utah State Office of Education

Christine O'Sullivan
K-12 Consulting
(Consultant for Educational Testing Service)

Senta A. Raizen
National Center for Improving Science Education

Ann Marie Zolandz
Educational Testing Service

Staff

National Center for Education Statistics

Marilyn Binkley

Patrick Gonzales

Andrew Malizio

Eugene Owen

Elois Scott

Education Statistics Services Institute

Kristy David

Janine Emerson

Kim Gattis

Dana Kelly

Teresa Smith Neidorf

Margaret Woodworth

American Institutes for Research

Maria Stephens

David Nohara
Independent Project Consultant

Appendix D. Methodological Notes and Supplementary Data

Considerations in Selecting Classification Methods

The cross-classification approach (classification of items in one assessment to the other assessment framework) was selected for the examination of content and grade fit so that there would be multiple content profiles for each assessment. This method also prevents either assessment from being evaluated through only one perspective, which may or may not be reflective of its purposes. This approach takes advantage of the multiple ways of describing content found in the frameworks and enables direct comparisons across the assessments.

For the classifications based on cognitive processes and scientific inquiry skills, common classification systems were chosen—the TIMSS 2003 *cognitive domain* and *scientific inquiry* dimensions. There were several reasons for deciding, first, to use common classification systems and, second, for selecting the TIMSS definitions as the common systems. With regard to the first decision, the study organizers recognized that classifications in these dimensions likely would require more discretionary judgment than those in content areas and thought a single rubric for each would be the most realistic to implement under the time constraints. With regard to the second decision, although other classification systems for both dimensions were reviewed,[1] the study organizers determined that, because the descriptions of *cognitive domain* and *scientific inquiry* in TIMSS are among the most recently developed and the most explicitly defined, they would be the most relevant for the comparison study and would provide sufficient guidance for panelists in making classifications. They also allow the panel's ratings to be compared with the developer's ratings, at least for the TIMSS items.

Reliability Analyses

For the classification of items, the expert panel was divided into three groups to review items by content area (as described in section III). To measure the extent to which the different content area groups were interpreting the common rubrics in similar ways, a common set of items was classified by all three groups with respect to *cognitive domain* and *scientific inquiry*. The degree to which the three groups classified these items in the same categories on these two dimensions serves as a measure of the reliability of these classifications. The set of 60 items (30 from NAEP and 30 from TIMSS), which reflects approximately 10 percent of the total item classifications across both assessments, was taken from across the science content areas and grade levels. This was not a random sample, but a representative set chosen to cover the main categories addressed in the study (content area and grade level). Some effort was also made to ensure that there were at least some items from each of the cognitive categories based on the original assessment developers' classifications (*cognitive domain* in TIMSS and *knowing and doing* in NAEP). In addition, some items classified as scientific inquiry/investigation by the original developers were included. Reliability items were classified at regular intervals throughout the classification process. Given the

[1] In looking for classification systems for cognitive domain, study organizers reviewed the National Science Education Standards (NRC 1996), the Benchmarks For Science Literacy (AAAS 1993), several studies on the alignment of state assessments and standards being conducted by the Council of Chief State School Officers (CCSSO), and select state assessments, in addition to TIMSS and NAEP. The first two sources also addressed scientific inquiry and so were considered for that rubric as well.

limited time available for the expert panel meeting, the 30 items from each assessment was the maximum number of items that could be included in the reliability set.

The multiple classification data for the reliability set were analyzed based on the percentage of classifications where there was agreement. Classification reliability statistics were computed in two ways, as follows:

- The percentage of total comparisons: based on the number of comparisons where there was agreement between any two groups (i.e., groups 1 and 2, groups 2 and 3, and groups 1 and 3) across ALL items and

- The percentage of items: based on the number of items where there was agreement across ALL three groups.

The results for these two types of analysis for the *cognitive domain* classifications are shown in tables D-1 and D-2, and the corresponding results for *scientific inquiry* classifications are shown in tables D-3 and D-4.

There was reasonably high agreement across groups on the classification to the three *cognitive domain* categories (*factual knowledge*, *conceptual understanding*, and *reasoning and analysis*). The lack of perfect agreement reflects the fact there is considerable overlap of skills/abilities covered by these types of cognitive categories. The results show 72 percent agreement for all comparisons between any two groups across all items (table D-1). These results reflect agreement across all three groups for 55 percent of all items (table D-2). The disagreements were always between "adjacent" categories (i.e., *factual knowledge/conceptual understanding* or *conceptual understanding/reasoning and analysis*). That is, there were no instances of disagreement between *factual knowledge* and *reasoning and analysis*. For all items where there was not total agreement across all three groups (45 percent overall), two of the three groups agreed and the third classified the item to an adjacent category. In some cases items were classified as being on the border between two adjacent categories by some groups; these were considered to be in agreement if they overlapped the classification of other groups. Collectively, when the reliability analyses are broken down into the NAEP and TIMSS items, the results are nearly the same.

Table D-1. Reliability of cognitive domain classifications for science items in NAEP 2000 and TIMSS 2003, by number of comparisons and percentage agreement

Number of comparisons and percentage agreement	NAEP 2000	TIMSS 2003	Overall
Total number of comparisons across items	90	90	180
Number of comparisons with agreement between groups	65	64	129
Percentage agreement	72	71	72

NOTE: Data are based on 30 NAEP items and 30 TIMSS items that were classified by three expert panel groups and reflect all comparisons between any two groups (i.e., groups 1 and 2; groups 2 and 3; and groups 1 and 3). Items that were classified on the border between two categories by some groups were counted as being in agreement with other groups if their categories overlapped.
SOURCE: Expert panel classifications of selected fourth- and eighth-grade science items from the National Assessment of Educational Progress (NAEP) 2000 Science Assessment and the Trends in International Mathematics and Science Study (TIMSS) 2003 Assessment.

Table D-2. Reliability of cognitive domain classifications for science items in NAEP 2000 and TIMSS 2003, by number of items and percentage agreement

Number of items and percentage agreement	NAEP 2000	TIMSS 2003	Overall
Total number of items	30	30	60
Number of items with agreement across all groups	17	16	33
Percentage agreement	57	53	55

NOTE: Data are based on 30 NAEP items and 30 TIMSS items that were classified by three expert panel groups and reflect comparisons across all three groups for each item. Items that were classified on the border between two categories by some groups were counted as being in agreement if their categories overlapped both of the other groups.
SOURCE: Expert panel classifications of selected fourth- and eighth-grade science items from the National Assessment of Educational Progress (NAEP) 2000 Science Assessment and the Trends in International Mathematics and Science Study (TIMSS) 2003 Assessment.

Compared to the *cognitive domain* classifications, there was higher agreement across groups on the *scientific inquiry* classifications (yes/no), but the agreement was higher for NAEP items than for TIMSS items. There was 83 percent agreement between any two groups across all items on the *scientific inquiry* classifications, with 90 percent agreement for the NAEP items and 76 percent agreement for the TIMSS items (table D-3). At the item level, 75 percent of items overall had agreement across all three groups (table D-4). This reflects 87 percent of NAEP items compared to 63 percent of TIMSS items. In a few cases items were classified as being borderline inquiry (yes/no) by some groups; these were considered to be in agreement with groups that classified the items as yes.

Table D-3. Reliability of scientific inquiry classifications for science items in NAEP 2000 and TIMSS 2003, by number of comparisons and percentage agreement

Number of comparisons and percentage agreement	NAEP 2000	TIMSS 2003	Overall
Total number of comparisons across items	90	90	180
Number of comparisons with agreement between groups	81	68	149
Percentage agreement	90	76	83

NOTE: Data are based on 30 NAEP items and 30 TIMSS items that were classified by three expert panel groups and reflect all comparisons between any two groups (i.e., groups 1 and 2; groups 2 and 3; and groups 1 and 3). Items that were classified as borderline (yes/no) by some groups were counted as being in agreement with other groups that classified the items as yes.
SOURCE: Expert panel classifications of selected fourth- and eighth-grade science items from the National Assessment of Educational Progress (NAEP) 2000 Science Assessment and the Trends in International Mathematics and Science Study (TIMSS) 2003 Assessment.

Table D-4. Reliability of scientific inquiry classifications for science items in NAEP 2000 and TIMSS 2003, by number of items and percentage agreement

Number of items and percentage agreement	NAEP 2000	TIMSS 2003	Overall
Total number of items	30	30	60
Number of items with agreement across all groups	26	19	45
Percentage agreement	87	63	75

NOTE: Data are based on 30 NAEP items and 30 TIMSS items that were classified by three expert panel groups and reflect comparisons across all three groups for each item. Items that were classified as borderline (yes/no) by some groups were counted as being in agreement with other groups that classified the items as yes.
SOURCE: Expert panel classifications of selected fourth- and eighth-grade science items from the National Assessment of Educational Progress (NAEP) 2000 Science Assessment and the Trends in International Mathematics and Science Study (TIMSS) 2003 Assessment.

In sum, the main focus of the present study is a content comparison—classification of items to the content framework of the other assessment—which was done by the separate content-area subpanels. The reliability tables are included only to provide some indication of the extent to which the expert panelists agreed on the other metrics that used a common rubric (*cognitive domain* and *scientific inquiry*). Expert panelists typically spent less time reviewing and classifying the items in the reliability set that were outside of their primary content area, and the results from these secondary classifications should not be viewed as a complete replication of the process used by the primary group which was most familiar with the items in the respective content area. Therefore, only the primary group classifications were used in the reporting of results for *cognitive domain* and *scientific inquiry*.

Data Processing

After the expert panel meeting, the facilitators of each group met to review the methods used and the data collected to ensure consistency. In some cases, methods or reporting conventions were slightly different between groups. For these cases, the facilitators reviewed their notes and the notes of individual panel members to standardize the data. Datasets were produced that included the standardized expert panel classifications for all items from each assessment (including multiple classifications on the reliability set) as well as original classification information for each item provided by the assessment developers. The raw data containing all original panelist classifications and comments from each subgroup were also available for analysts and were consulted in the writing of this report.

Appendix E. Example Items

Exhibit E-1. Index of example items from NAEP 2000[1] and TIMSS 2003

Example number	Description of characteristics illustrated in text
1	NAEP cross-grade life science item administered at grades 4 and 8 classified at the eighth-grade level on TIMSS 2003 science framework
2	NAEP fourth-grade item classified as scientific inquiry
3	TIMSS eighth-grade environmental science item classified as scientific inquiry
4	NAEP eighth-grade multiple-choice physical science item classified as measuring conceptual understanding
5	NAEP fourth-grade physical science item classified at the eighth-grade level on the TIMSS 2003 science framework
6	TIMSS fourth-grade chemistry item not classified to a topic on the NAEP 2000 science framework
7	TIMSS eighth-grade chemistry item not classified to a topic on the NAEP 2000 science framework
8	NAEP fourth-grade physical science item from the topic of energy and transformations
9	TIMSS eighth-grade life science item classified at the twelfth-grade level on the NAEP 2000 science framework
10	TIMSS eighth-grade life science item from the topic of human health not classified to a topic in the NAEP 2000 science framework
11	NAEP eighth-grade life science item from the topic of interdependence of life
12	NAEP fourth-grade Earth science item classified as eighth-grade environmental science on the TIMSS 2003 science framework
13	TIMSS fourth-grade Earth science item classified at the eighth-grade level on the NAEP 2000 science framework
14	TIMSS fourth-grade Earth science item not classified to a topic on the NAEP 2000 science framework
15	TIMSS eighth-grade Earth science item classified at the twelfth-grade level on the NAEP 2000 science framework
16	TIMSS eighth-grade environmental science item classified as fourth-grade physical science on the NAEP 2000 science framework
17	TIMSS fourth-grade environmental science item classified as life science on the NAEP 2000 science framework
18	TIMSS eighth-grade environmental science item classified as Earth science on the NAEP 2000 science framework

Full tasks	Description
Task 1	NAEP eighth-grade hands-on task from the NAEP 1996 science assessment (Salt Solutions)
Task 2	TIMSS eighth-grade problem solving and inquiry task (Metal Crown)

[1] A NAEP task from the 1996 assessment (Task 1) is included as an example to illustrate the type of hands-on tasks used in NAEP. No hands-on tasks from the 2000 NAEP assessment have been released.

EXAMPLE 1

NAEP short constructed-response item – grades 4 and 8

Suppose that one spring a new type of large fish was put into the pond. So many were put in that there were twice as many fish as before. By the end of the summer, what would happen to the large fish that were already in the pond?

Explain why you think these new large fish would have this effect.

SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2000 Science Assessment.

Scoring guide

Complete Student provides a response showing clear understanding of competition and its effect on population.
Partial Student provides a response that shows an understanding of competition, but not of the consequences. OR Student provides a response that shows a reasonable consequence and gives a plausible reason not based on competition.
Unsatisfactory/Incorrect Student provides a response that shows no understanding of the concept of interspecific competition, answering that there will be more of the large fish already in the pond, or that the two kinds of fish would be friends, etc. OR Student responds that one type of fish would die and gives no reason or an implausible reason.

Framework classifications

NAEP content framework[1]	TIMSS content framework[2]
Life science	Life science
Ecology	
The interdependence of life: populations, communities, and ecosystems	Ecosystems
Grade 4	Grade 8
TIMSS cognitive domain:[2] conceptual understanding	
Scientific inquiry classification:[2] no	

[1]Classified by NAEP assessment developers
[2] Classified by expert panel

EXAMPLE 2

NAEP short constructed-response item – grade 4

You are going to the park on a hot day and need to take some water with you. You have three different bottles, as shown in the picture below. You want to choose the bottle that will hold the most water. Explain how you can find out which bottle holds the most water.

SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2000 Science Assessment.

Scoring guide

Complete Student demonstrates an understanding of how to measure and compare the volumes of three different bottles by outlining a method for finding which bottle holds the most water.
Partial Student demonstrates some understanding, but does not state a specific method.
Unsatisfactory/Incorrect Student response is based on the shape or height of the bottle, not on its volume. Student may also compare the time required to pour water out of each bottle.

Framework classifications

NAEP content framework[1]	TIMSS content framework[2]
Physical science	Chemistry
Matter and its transformations	
Diversity of matter (materials): classification and types, particulate nature of matter, conservation of matter	Classification and composition of matter
Grade 4	Grade 4
TIMSS cognitive domain:[2] reasoning and analysis	
Scientific inquiry classification:[2] yes	

[1]Classified by NAEP assessment developers
[2]Classified by expert panel

EXAMPLE 3

TIMSS extended constructed-response item – grade 8

Sea water contains dissolved salts and is not suitable for drinking. Describe a procedure that can be used to obtain a cup of drinking water from a bucket of sea water.

SOURCE: International Association for the Evaluation of Educational Achievement, Trends in International Mathematics and Science Study (TIMSS), 2003 Assessment.

Scoring guide

Correct Describes a correct procedure that includes the following basic steps (may use diagrams). i) Boiling/evaporation to separate water from salt. ii) Collecting the distilled water (condensation). [May describe other correct procedures such as freezing method or reverse osmosis method.]
Partial Describes boiling/evaporation step to separate water from salt; condensation step is omitted. OR States "distillation" or similar but no description of the process is given.
Incorrect Mentions boiling process but with no or incorrect indication of separation included. OR Mentions filtering to separate salt.

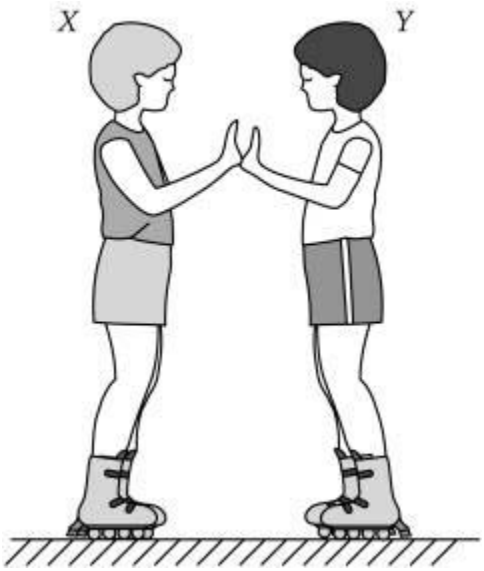
Framework classifications

TIMSS content framework[1]	NAEP content framework[2]	
	Multiple classification	
Environmental science	Physical science	Earth science
	Matter and its transformations	Water (hydrosphere)
Use and conservation of natural resources	Temperature and states of matter (physical changes)	The location of water, its distribution, characteristics, effect of and influence on human activity
Grade 8	Grade 8	Grade 8
TIMSS cognitive domain:[2] reasoning and analysis		
Scientific inquiry classification:[2] yes		

[1]Classified by TIMSS assessment developers
[2]Classified by expert panel

EXAMPLE 4

NAEP multiple choice item – grade 8



Two boys wearing in-line skates are standing on a smooth surface with the palms of their hands touching and their arms bent, as shown above. If Boy X pushes by straightening his arms out while Boy Y holds his arms in the original position, what is the motion of the two boys?

A) Boy X does not move and Boy Y moves backward.
B) Boy Y does not move and Boy X moves backward.
C) Boy X and Boy Y both move backward.
D) The motion depends on how hard Boy X pushes.

SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2000 Science Assessment.

Answer Key: C

Framework classifications

NAEP content framework[1]	TIMSS content framework[2]
Physical science	Physics
Motion	
Action and reaction	Forces and motion
Grade 8	Grade 8
TIMSS cognitive domain:[2] conceptual understanding	
Scientific inquiry classification:[2] no	

[1]Classified by NAEP assessment developers
[2]Classified by expert panel

EXAMPLE 5

NAEP multiple-choice item – grade 4

There is a thunderstorm close to your house. The windows rattle at the same time that you hear the thunder. What causes the windows to rattle?

A) Sound waves from the thunder

B) Light from the lightning

C) Rain from the clouds

D) The high humidity during the storm

SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2000 Science Assessment

Answer Key: A

Framework classifications

NAEP content framework[1]	TIMSS content framework[2]
Physical science	Physics
Motion	
Vibration and waves as motion (includes sound)	Sound and vibration
Grade 4	Grade 8
TIMSS cognitive domain:[2] conceptual understanding	
Scientific inquiry classification:[2] no	

[1]Classified by NAEP assessment developers
[2]Classified by expert panel

EXAMPLE 6

TIMSS multiple-choice item – grade 4

Which of these activities will result in a different kind of material being formed?

A) A nail is left outside and it rusts.
B) A glass is dropped and it shatters into small pieces.
C) A rubber band is stretched until it breaks.
D) A pencil is sharpened to a point.

SOURCE: International Association for the Evaluation of Educational Achievement, Trends in International Mathematics and Science Study (TIMSS), 2003 Assessment.

Answer Key: A

Framework classifications

TIMSS content framework[1]	NAEP content framework[2]
Chemistry	Physical science
	Matter and its transformations
Chemical change	No match at subtopic level
Grade 4	Grade 4
TIMSS cognitive domain:[2] conceptual understanding	
Scientific inquiry classification:[2] no	

[1]Classified by TIMSS assessment developers
[2]Classified by expert panel

EXAMPLE 7

TIMSS short constructed-response item – grade 8

A solution of hydrochloric acid (HCl) in water will turn blue litmus paper red. A solution of the base sodium hydroxide (NaOH) in water will turn red litmus paper blue. If the acid and base solutions above are mixed in the right proportion, the resulting solution will cause neither red nor blue litmus paper to change color.

Explain why the litmus paper does not change color in the mixed solution.

SOURCE: International Association for the Evaluation of Educational Achievement, Trends in International Mathematics and Science Study (TIMSS), 2003 Assessment.

Scoring guide

Correct Explanation refers explicitly to the formation of water (and salt) from the neutralization reaction. [Responses may use words or a chemical equation. The equation does not need to be completely correct for credit as long as neutralization is clear.] OR Explanation refers explicitly to neutralization (or equivalent), but the specific reaction is not mentioned. OR Explanation refers to a chemical reaction taking place (implicitly or explicitly) to form products that do not react with litmus paper (or similar). [Neutralization is not explicitly mentioned.]
Incorrect Mentions only that acid and base are "balanced", "opposites", "cancel each other", or similar.

Framework classifications

TIMSS content framework[1]	NAEP content framework[2]
Chemistry	Physical science
	Matter and its transformations
Acids and bases	No match at subtopic level
Grade 8	Grade 8
TIMSS cognitive domain:[2] conceptual understanding	
Scientific inquiry classification:[2] no	

[1]Classified by TIMSS assessment developers
[2]Classified by expert panel

EXAMPLE 8

NAEP multiple-choice item – grade 4

Beans and coal have stored energy. Where did the energy come from that is stored in beans and coal?

A) From the Earth's gravity
B) From the Sun's light
C) From the heat in the Earth's core
D) From the air's carbon dioxide

SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2000 Science Assessment.

Answer Key: B

Framework classifications

NAEP content framework[1]	TIMSS content framework[2]
Physical science	Physics
Energy and its transformations	
Energy sources and use, including distribution, conversion, costs, and depletion	Energy types, sources and conversions
Grade 4	Grade 4
TIMSS cognitive domain:[2] conceptual understanding	
Scientific inquiry classification:[2] no	

[1]Classified by NAEP assessment developers
[2]Classified by expert panel

EXAMPLE 9

TIMSS multiple-choice item – grade 8

Animals and plants are made up of a number of different chemical elements. What happens to all of these elements when animals and plants die?

A) They die with the animal or plant.
B) They evaporate into the atmosphere.
C) They are recycled back into the environment.
D) They change into different elements.

SOURCE: International Association for the Evaluation of Educational Achievement, Trends in International Mathematics and Science Study (TIMSS), 2003 Assessment

Answer Key: C

Framework classifications

TIMSS content framework[1]	NAEP content framework[2]
Life science	Life science
	Ecology
Ecosystems	The interdependence of life: populations, communities, and ecosystems
Grade 8	Grade 12
TIMSS cognitive domain:[2] conceptual understanding	
Scientific inquiry classification:[2] no	

[1]Classified by TIMSS assessment developers
[2]Classified by expert panel

EXAMPLE 10

TIMSS multiple-choice item – grade 8

Eating leafy vegetables is important for human health. This is because leafy vegetables are a good source of which of the following?

A) protein
B) carbohydrates
C) minerals
D) fat

SOURCE: International Association for the Evaluation of Educational Achievement, Trends in International Mathematics and Science Study (TIMSS), 2003 Assessment.

Answer Key: C

Framework classifications

TIMSS content framework[1]	NAEP content framework[2]
Life science	Life science
	Organisms
Human health	No match at subtopic level
Grade 8	Grade 8
TIMSS cognitive domain:[2] factual knowledge	
Scientific inquiry classification:[2] no	

[1]Classified by TIMSS assessment developers
[2]Classified by expert panel

EXAMPLE 11

NAEP multiple-choice item – grade 8

If air pollution causes the rain that falls on this pond to become much more acidic, after two years how will this acidity affect the living things in this pond?

A) There will be more plants and animals because the acid is a source of food.
B) There will be fewer plants and animals because the acid will dissolve many of them.
C) There will be fewer plants and animals because many of them cannot survive in water with high acidity.
D) There will be more plants and animals because the acid will kill most of the disease-causing microorganisms.

SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2000 Science Assessment.

Answer Key: C

Framework classifications

NAEP content framework[1]	TIMSS content framework[2]
Life science Ecology The interdependence of life: populations, communities and ecosystems Grade 8	Life science Ecosystems Grade 8
TIMSS cognitive domain:[2] conceptual understanding	
Scientific inquiry classification:[2] no	

[1]Classified by NAEP assessment developers
[2]Classified by expert panel

EXAMPLE 12

NAEP extended constructed-response item – grade 4

Garbage is a big problem. In many cities and towns, garbage is taken away to landfills, which are often called dumps. Some landfills are very big and may cover hundreds of acres. But even these big landfills are getting full and may have to be closed.

Here are some ideas for solving the garbage problem. Write what you think is a good point about each idea and what you think is a bad point about each idea.

Ideas for Solving Garbage Problem	Good Points	Bad Points
Recycling		
Burning garbage		
Dumping garbage in the ocean		
Sending garbage to a landfill in another state		
Shipping garbage to outer space		

SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2000 Science Assessment.

EXAMPLE 12 — continued

Scoring guide

Complete The student is asked to provide ten explanations, one good and one bad for five proposed solutions for dealing with garbage. A complete response provides eight to ten correct explanations.
Essential An essential response provides six or seven correct explanations.
Adequate An adequate response provides three to five correct explanations.
Partial A partial response provides one or two correct explanations.
Unsatisfactory An unsatisfactory response provides no correct explanations.

Framework classifications

NAEP content framework[1]	TIMSS content framework[2]
Earth science	Environmental science
Solid Earth (lithosphere)	
Resources from the Earth used by humankind	Use and conservation of natural resources
Grade 4	Grade 8
TIMSS cognitive domain:[2] reasoning and analysis	
Scientific inquiry classification:[2] no	

[1]Classified by NAEP assessment developers
[2]Classified by expert panel

EXAMPLE 13

TIMSS multiple-choice item – grade 4

Katie sees a full moon. About how much time will go by before the next full moon?

A) one week
B) two weeks
C) one month
D) one year

SOURCE: International Association for the Evaluation of Educational Achievement, Trends in International Mathematics and Science Study (TIMSS), 2003 Assessment.

Answer Key: C

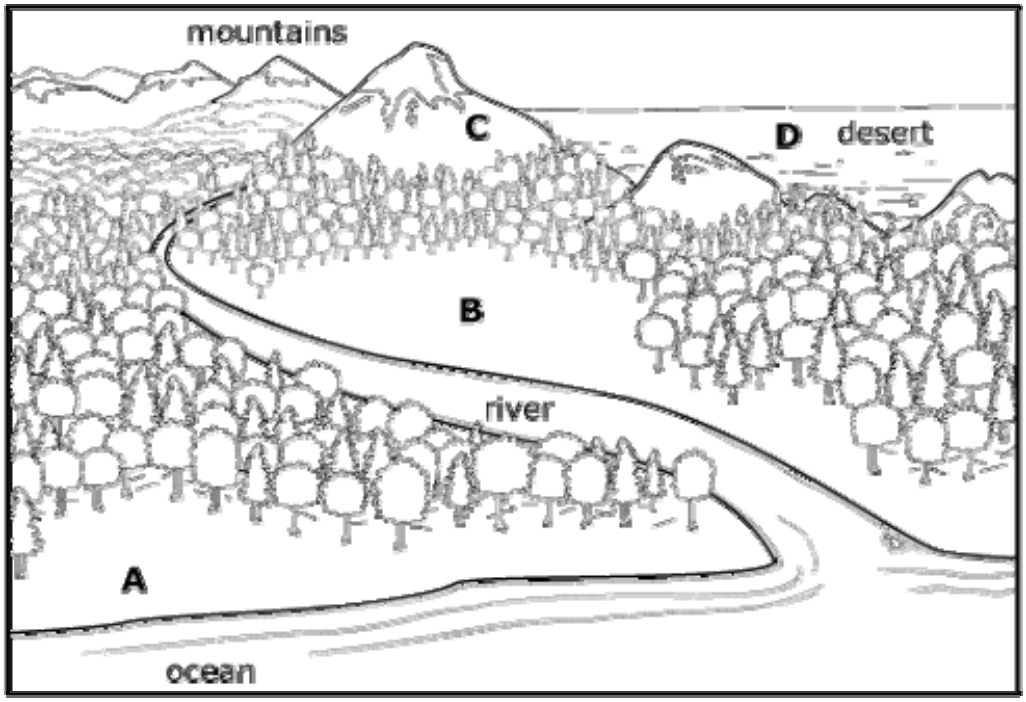
Framework classifications

TIMSS content framework[1]	NAEP content framework[2]
Earth science	Earth science
	Earth in space
Earth in the solar system and the universe	The setting of the Earth in the solar system
Grade 4	Grade 8
TIMSS cognitive domain:[2] factual knowledge / conceptual understanding	
Scientific inquiry classification:[2] no	

[1]Classified by TIMSS assessment developers
[2]Classified by expert panel

EXAMPLE 14

TIMSS multiple-choice item – grade 4



Look at the picture above. Where is the best location to grow crops?

A) Location A
B) Location B
C) Location C
D) Location D

SOURCE: International Association for the Evaluation of Educational Achievement, Trends in International Mathematics and Science Study (TIMSS), 2003 Assessment.

Answer Key: B

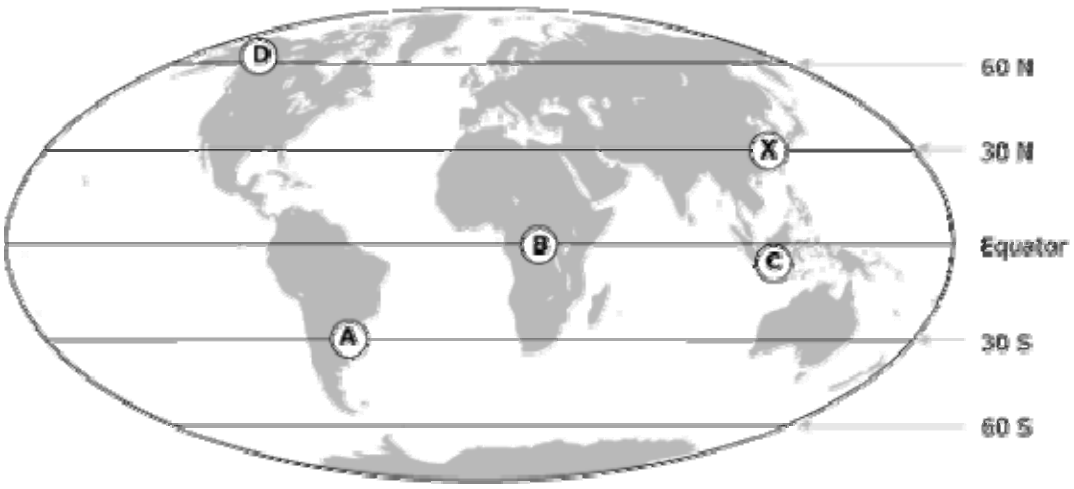
Framework classifications

TIMSS content framework[1]	NAEP content framework[2]
Earth science	Earth science
	Solid Earth (lithosphere)
Earth's structure and physical features	No match at the subtopic level
Grade 4	Grade 8
TIMSS cognitive domain:[2] reasoning and analysis	
Scientific inquiry classification:[2] no	

[1]Classified by TIMSS assessment developers
[2]Classified by expert panel

EXAMPLE 15

TIMSS multiple-choice item – grade 8



The diagram above shows a map of the world with the lines of latitude marked. Which of the following places marked on the map is the most likely to have an average yearly temperature similar to location X?

A) location A
B) location B
C) location C
D) location D

SOURCE: International Association for the Evaluation of Educational Achievement, Trends in International Mathematics and Science Study (TIMSS), 2003 Assessment.

Answer Key: A

Framework classifications

TIMSS content framework[1]	NAEP content framework[2]
Earth science	Earth science
	Air (atmosphere)
Earth's processes, cycles, and history	Climate
Grade 8	Grade 12
TIMSS cognitive domain:[2] reasoning and analysis	
Scientific inquiry classification:[2] yes	

[1]Classified by TIMSS assessment developers
[2]Classified by expert panel

EXAMPLE 16

TIMSS multiple-choice item – grade 8

Which group of energy sources are ALL renewable?

A) coal, oil, and natural gas
B) solar, oil, and geothermal
C) wind, solar, and tidal
D) natural gas, solar, and tidal

SOURCE: International Association for the Evaluation of Educational Achievement, Trends in International Mathematics and Science Study (TIMSS), 2003 Assessment.

Answer Key: C

Framework classifications

TIMSS content framework[1]	NAEP content framework[2]
Environmental science	Physical science
	Energy and its transformations
Use and conservation of natural resources	Energy sources and use, including distribution, conversion, costs, and depletion
Grade 8	Grade 4
TIMSS cognitive domain:[2] factual knowledge	
Scientific inquiry classification:[2] no	

[1]Classified by TIMSS assessment developers
[2]Classified by expert panel

EXAMPLE 17

TIMSS short constructed-response item – grade 4

Write down what happens to plants and fish in a river when a factory pours large amounts of hot water into the river.

SOURCE: International Association for the Evaluation of Educational Achievement, Trends in International Mathematics and Science Study (TIMSS), 2003 Assessment.

Scoring guide

Correct Response Explains that some species will die; others will be more abundant. OR Explains that many plants and fishes die. OR Explains that fish try to leave.
Incorrect The description or explanation given is not adequate.

Framework classifications

TIMSS content framework[1]	NAEP content framework[2]
	Primary classification
Environmental science	Life science
	Ecology
Changes in environments	No match at the subtopic level
Grade 4	Grade 8
TIMSS cognitive domain:[2] reasoning and analysis	
Scientific inquiry classification:[2] yes	

[1]Classified by TIMSS assessment developers
[2]Classified by expert panel

EXAMPLE 18

TIMSS extended constructed-response item – grade 8

The surface of Earth has more water than land. Write down TWO reasons why some people still do not have enough water to drink.

1.

2.

SOURCE: International Association for the Evaluation of Educational Achievement, Trends in International Mathematics and Science Study (TIMSS), 2003 Assessment.

Scoring guide

Note: Each of the two responses is coded separately. The same code may be used twice if they are based on general categories. However, if the two responses are essentially the same, the second response should be coded as an incorrect response.
Correct Mentions unsuitability of salt water for human consumption. OR Mentions climate or uneven distribution of rain/water. OR Mentions pollution as a cause. OR Mentions reasons related to population, water consumption, or waste of water. OR Mentions economic/technical factors (cost of transportation, water treatment). OR Mentions that much of the Earth's water is frozen in icebergs, glaciers, etc.
Incorrect response Mentions only water in clouds. Response too vague.

Framework classifications

TIMSS content framework[1]	NAEP content framework[2]
Environmental science	Earth science
Use and conservation of natural resources	Water (hydrosphere) The location of water, its distribution, characteristics, effect of and influence on human activity
Grade 8	Grade 8
TIMSS cognitive domain:[2] conceptual understanding	
Scientific inquiry classification:[2] no	

[1]Classified by TIMSS assessment developers
[2]Classified by expert panel

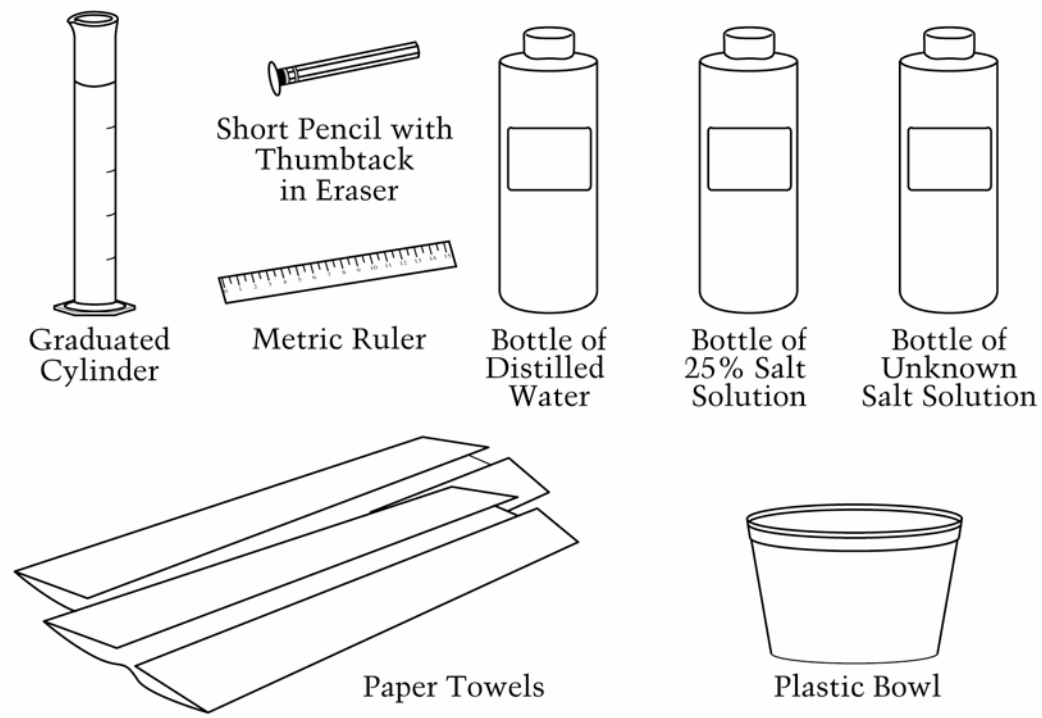
TASK 1

NAEP 1996 hands-on task – grade 8

SALT SOLUTIONS

Estimating the Salt Concentration of an Unknown Salt Solution
Using the "Floating Pencil Test"

For this task, you have been given a kit that contains materials that you will use to perform an investigation during the next 30 minutes. Please open your kit now and use the following diagram to check that all of the materials in the diagram are included in your kit. If any materials are missing, raise your hand and the administrator will provide you with the materials that you need.



Task 1—continued

NAEP 1996 hands-on task – grade 8

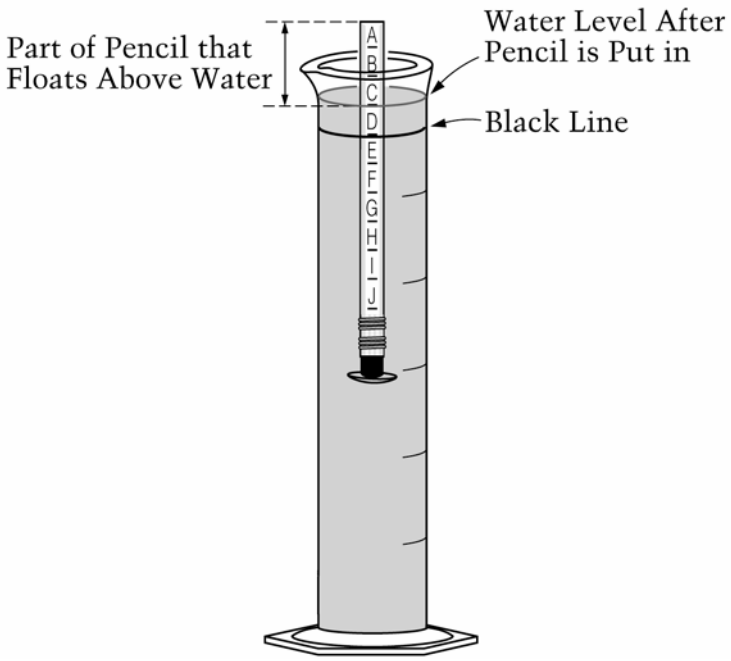
Every body of water in natural ecosystems has salts and other substances dissolved in it. The concentration of dissolved salt varies from less than 0.2 percent in most freshwater streams and lakes to about 3.5 percent in most of the world's oceans. In this task, you will observe and measure how much of the length of a pencil floats above the water surface in water with very low salt concentration and in water with very high salt concentration. You will then use the same procedures to estimate the salt concentration of an unknown solution. Follow the directions step-by-step and write your answers to the questions in the space provided in your booklet.

Task 1—continued

NAEP 1996 hands-on task – grade 8

1. Open the plastic bottle labeled **Distilled Water**. The salt concentration of this water is very close to 0 percent. Pour the distilled water into the cylinder up to the black line. Put the cap back on the bottle.

Now take the pencil and put it in the water in the cylinder, eraser-end down. Part of the pencil will float above the water, as shown in the picture below.

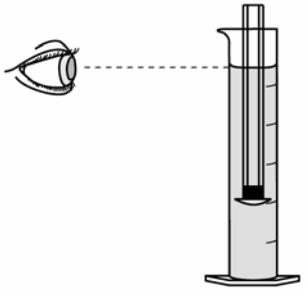


Explain why the pencil floats when it is put in the water.

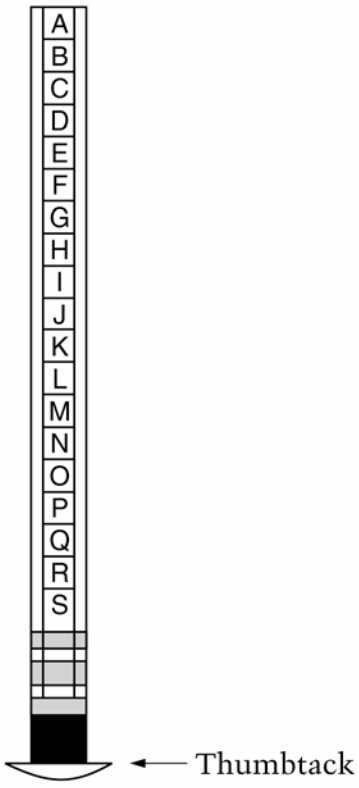
Task 1—continued

NAEP 1996 hands-on task – grade 8

2. Look at the pencil in the water. There are letters along the side of the pencil. Make sure that the pencil is not touching the side of the cylinder. Note the exact level where the water surface meets the side of the pencil, as shown in Picture A. Then draw a line on Picture B where the water surface comes to on your pencil. This line will help you to remember where the water level came to on your pencil for the next step (3).



Picture A



Picture B

3. Now take the pencil out of the water and dry it with a paper towel. Use the ruler to measure the length of the pencil that was above the water. Record the length in Table 1 below under **Measurement 1**.

TABLE 1

Type of Solution	Length of Pencil Above Water Surface (cm)		
	Measurement 1	Measurement 2	Average
Distilled Water			
Salt Solution			
Unknown Salt Solution			

4. Now place the pencil back in the distilled water and repeat steps 2 and 3. Record your measurement in Table 1 under **Measurement 2.**

5. Calculate the average of Measurements 1 and 2 and record the result in the data table. (You can calculate the average by adding Measurement 1 + Measurement 2 and then dividing by two.)

6. Explain why it is better to measure the length of the pencil that was above the water more than once.

Now pour the distilled water out of the cylinder into the large plastic bowl. Later you will throw this water away.

Open the plastic bottle labeled **Salt Solution**. This solution contains 25% salt. Pour the salt solution into the cylinder up to the black line. Put the cap back on the bottle.

7. Now take the pencil and put it in the 25% salt solution in the cylinder, eraser-end down. How does the pencil float in this solution compared to how it floated in the distilled water? (Fill in the oval in front of the correct answer.)

- ⬭ In the salt solution, more of the pencil is above the surface.
- ⬭ In the salt solution, more of the pencil is below the surface.

Task 1—continued

NAEP 1996 hands-on task – grade 8

8. Now use the same procedure that you used with the pencil in the distilled water to obtain two measurements of the length of the pencil that floats above the surface of the 25% salt solution. Record these two measurements in Table 1. Then calculate the average and record this result in the table.

9. Why does the pencil float at a different level in the salt solution than in the distilled water?

_____

_____

_____

_____

_____

10. If you added more salt to the 25% salt solution and stirred the solution until the salt was dissolved, how would this change the way that the pencil floats? (Fill in the oval in front of the correct answer.)

- ⬭ Less of the pencil would be above the surface.
- ⬭ More of the pencil would be above the surface.
- ⬭ There would be no difference in the amount of pencil above the surface.

Now pour the 25% salt solution out of the cylinder into the large plastic bowl. Later you will throw this solution away.

Task 1—continued

NAEP 1996 hands-on task – grade 8

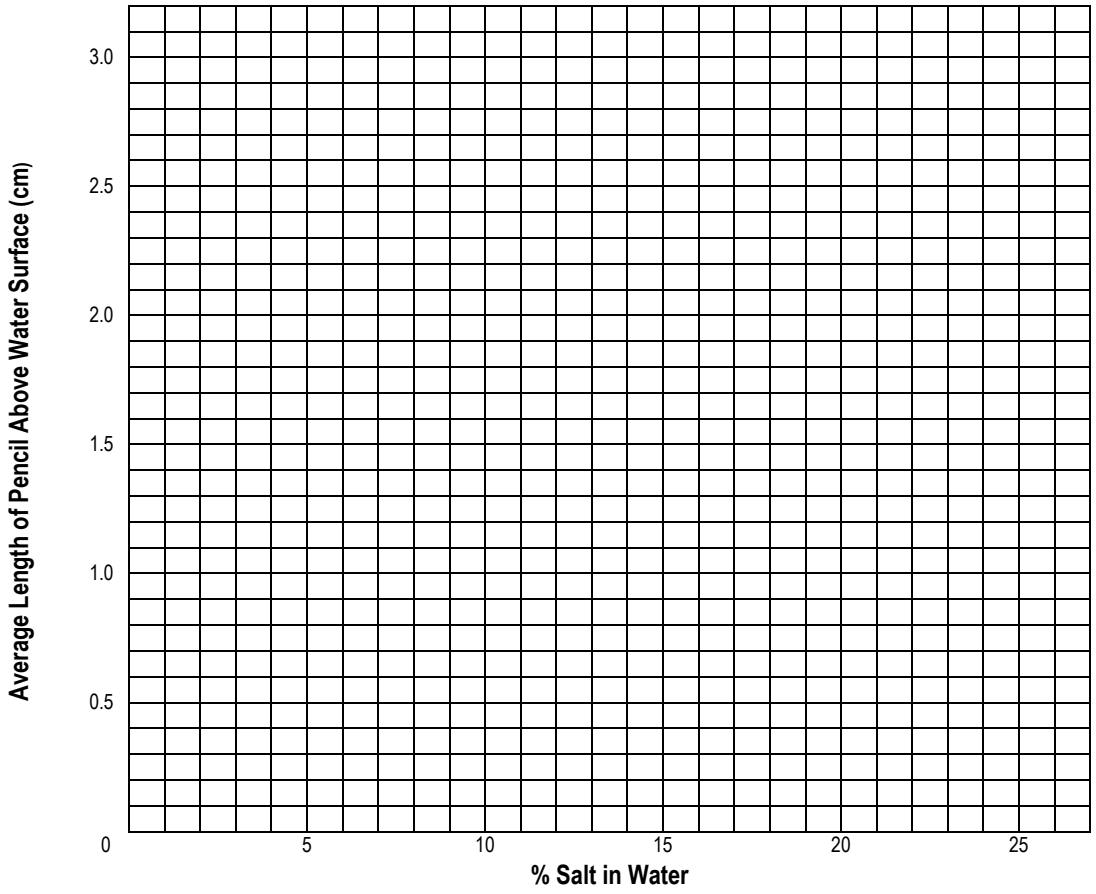
Now open the plastic bottle labeled **Unknown Salt Solution**. You will now estimate the concentration of this unknown salt solution. Pour the unknown solution into the cylinder up to the black line. Put the cap back on the bottle.

11. Put the pencil in the solution in the cylinder, eraser-end down. Then repeat the same procedure that you used for the distilled water and the 25% salt solution. Obtain two measurements of the length of the pencil that floats above the surface of the unknown salt solution. Record these two measurements in Table 1. Then calculate the average and record this result in the table.

Task 1—continued

NAEP 1996 hands-on task – grade 8

12. On the graph below, plot the average values you obtained for the distilled water and the 25% salt solution. Draw a straight line between the two data points. Assume that this line represents the relationship between the length of pencil that is above the water surface and the concentration of salt in the water.



13. Based on the graph that you plotted, how does the length of the pencil that is above the surface change when the salt concentration changes? (Fill in the oval in front of the correct answer.)

- ⬭ It increases as the salt concentration increases.
- ⬭ It decreases as the salt concentration increases.
- ⬭ It remains constant as the salt concentration increases.

Task 1—continued

NAEP 1996 hands-on task – grade 8

14. Based on the graph that you plotted, what is the salt concentration of the unknown solution?

Task 1—continued

NAEP 1996 hands-on task – grade 8

Scoring guides

Item 1

Complete Student response explains that the pencil floats because it (or the wood of the pencil) is less dense than water.
Essential Student response mentions density in some correct reasonable way, but does not clearly say that the pencil is less dense than water.
Partial Student response demonstrates partial understanding of why the pencil floats or a reference to buoyancy, weight, pressure, forces, or lightness is made, but no mention is made of the key concept of density.
Unsatisfactory/Incorrect Student response indicates a lack of understanding of the fact that the wood of the pencil is less dense than water.

Items 3, 4, 8, and 11

Rationale: Student demonstrates an ability to accurately observe, measure, and record the length of the pencil floating above the water surface. In each case, the student measures two lengths that are within +/- 0.2 cm or += 1/16 inch of each other. The distilled water should have the lowest value, the salt solution the highest.
Complete All three sets of measurements agree within tolerances, and the relative order of the solutions is correct.
Essential All three sets of measurements agree within tolerances, but the relative order is incorrect.
Partial Only two sets of measurements agree within tolerances.
Unsatisfactory/Incorrect One or no sets of measurements agree within tolerances.

Items 5, 8, and 11, which are scored together

Rationale: Student demonstrates an ability to accurately calculate the average of two measurements.
Complete All three of the student-calculated averages is within +/- .01 cm. or +/- 1/32 inch of the correct average, as calculated from the measurements taken by the student.
Partial Two of the three student-calculated averages is within +/- .01 cm. or +/- 1/32 inch of the correct average, as calculated from the measurements taken by the student. OR One of the three student-calculated averages is within +/- .01 cm. or +/- 1/32 inch of the correct average, as calculated from the measurements taken by the student.
Unsatisfactory/Incorrect None of the three student-calculated averages is within +/- .01 cm. or +/- 1/32 inch of the correct average, as calculated from the measurements taken by the student.

Task 1—continued

NAEP 1996 hands-on task – grade 8

Scoring guides

Item 6

Rationale: Student demonstrates an understanding of the concept of uncertainty (and error) in measurement by explaining that error in measurement can be reduced by taking several measurements and calculating their average.
Complete Student response acknowledges the differences between consecutive measurements and the fact that error is reduced when an average of several measures is obtained.
Partial Student response makes a reference to variability of measurement without providing a complete explanation. OR Student response refers to making a mistake when measuring. OR Student response refers to taking an average without mentioning the variability of measurements.
Unsatisfactory/Incorrect Student response fails to acknowledge that a different answer might be obtained every time a measurement is made (i.e., that by making three measurements and dividing by three, error is reduced).

Item 7

Correct answer: In the salt solution, more of the pencil is above the surface.

Item 9

Rationale: Student demonstrates an understanding of the concept of relative density by explaining that the salt in the 25% salt solution causes this solution to have a higher density relative to the wood in the pencil than the distilled water does, and that the higher the relative density, the higher the pencil will float.
Complete Student response indicates that the 25% salt solution is more dense that the distilled water, and may say that the pencil floats higher in the solution that is more dense.
Partial Student response fails to identify the difference in density between the 25% salt solution and the distilled water, but does make reference to a difference between the two. The student may also refer to density of the salt solution, but compare it to the pencil instead of the distilled water.
Unsatisfactory/Incorrect Student response fails to indicate that the 25% salt solution is more dense than the distilled water, and that this difference accounts for the pencil floating higher in the salt solution than in the distilled water.

Item 10

Correct answer: More of the pencil would be above the surface.

Task 1—continued

NAEP 1996 hands-on task – grade 8

Scoring guides

Item 12

Rationale: Student demonstrates an ability to accurately plot two data points and connect these points with a straight line. The graph should match student data.
Note: Points will be accepted as correct if they are within one line of exact value. Vertical lines or bars also okay. The points should be clearly marked on the graph – if there are more than two and there is no line drawn, score as Unsatisfactory/Incorrect.
Complete Student correctly plots the results for both the distilled water and the salt solution and draws a line between the two data points.
Partial Student correctly plots one point required to draw the line but not both. OR Student plots both points correctly but fails to connect them with a straight line, or does not connect them.
Unsatisfactory/Incorrect Student fails to accurately plot the results for both the distilled water and the salt solution.

Item 13

Correct answer: It increases as the salt concentration increases.

Item 14

Rationale: Student demonstrates an ability to accurately make inferences from a line graph (or from data if the student does not have a good graph).
Complete Student gives a salt concentration consistent with the data and a satisfactory explanation is provided as to how the answer was obtained (i.e., by reading off the graph the point on the X-axis (% salt concentration) at which the point on the Y-axis (length of pencil above the water) intersects the line drawn by the student). Proportional reasoning is also appropriate. If attempt to explain is not clear or exactly correct, a point or other indication on the graph is acceptable.
Essential Student gives a salt concentration consistent with the graph, but does not give a correct explanation as to how the answer was obtained, or explains how to use the graph but makes an error in the value.
Partial Student response shows a use of proportional reasoning in the explanation, or an unclear explanation of how to use the graph, but does not have a graph that could be used to interpolate, or student uses the graph incorrectly.
Unsatisfactory/Incorrect Student does not obtain a value consistent with the graph and does not give a correct explanation of the acceptable method of interpolation.

SOURCE: U.S. Department of Education, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 1996 Science Assessment.

TASK 2

TIMSS 2003 problem solving and inquiry task – grade 8

Metal Crown
Instructions: Questions 1,2, 3, and 4 are about an investigation of the properties of a metal crown. To answer these questions, you may use any information shown on the pages in the Metal Crown section.

A king gave a jeweler a block of pure metal. He asked the jeweler to make him a crown out of the metal.


metal crown


metal block

After the jeweler delivered the crown, the king observed it carefully. He thought that the jeweler might have substituted another pure metal or a mixture of metals to make the crown. He weighed the crown, and it had the same mass as the original block, 2400 grams. Still not satisfied, the king asked some scientists to help him find out what the crown was made of.

Questions for Metal Crown begin on the next page. ➡

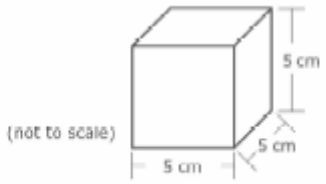
Task 2—continued

TIMSS 2003 problem solving and inquiry task – grade 8

Question 1

The scientists decided to compare the densities of the crown and a block of metal just like the original block. The density of a substance is the mass of a sample of the substance divided by its volume (density = mass/volume).

The scientists found the volume of the block and computed its density based on its known mass (2400g). The diagram below shows the dimensions of the block of metal that the scientists measured.



What is the density of the block of metal?

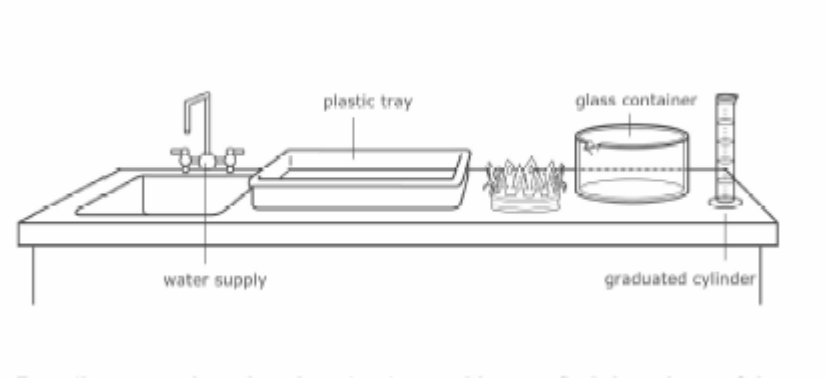
Answer: _____ g/cm^3

Task 2—continued

TIMSS 2003 problem solving and inquiry task – grade 8

Question 2

The scientists then needed to find the volume of the crown in order to determine its density. The following equipment and materials were available for them to use.



Describe a procedure that the scientists could use to find the volume of the crown using some or all of the equipment and materials shown above. You may use diagrams to help explain your procedure.

Task 2—continued

TIMSS 2003 problem solving and inquiry task – grade 8

Question 3

The scientists measured the volume of the crown five times. They computed the density for each volume measurement. Their results are shown in the table below.

Trial	Volume of Crown (cm^3)	Density of Crown (g/cm^3)
1	202	11.88
2	200	12.00
3	201	11.94
4	198	12.12
5	199	12.06

A. Why did the scientists measure the volume five times?

B. The scientists reported to the kind that the density of the crown was 12.0 g/cm^3. Show how the scientists used their results to obtain this value for the density.

Task 2—continued

TIMSS 2003 problem solving and inquiry task – grade 8

Question 4

The table below lists the density for different metals.

Metal	Density (g/cm^3)
Platinum	21.4
Gold	19.3
Silver	10.5
Copper	8.9
Zinc	7.1
Aluminum	2.7

A. Look at the density you computed for the block of metal. What was the block of metal most likely made of?

Answer: _____
Explain your answer.

B. The density of the crown was found to be 12.0 g/cm^3. What would you report to the king about what metal or mixture of metals the jeweler used to make the crown?

Task 2—continued

TIMSS 2003 problem solving and inquiry task – grade 8

Scoring guides

Question 1

Correct response 19.2 g/cm3 [extra trailing zeroes may also be added]. OR 19 g/cm3 [rounds to nearest whole unit].
Incorrect response Shows the set up for density (mass/volume) but does not compute density or makes a computational error. OR 125 [Computes volume but not density]. OR 19.3 [No work shown; indicates density copied from table.]

Question 2

Correct Response Describes or diagrams a procedure based on displacement of water using measured water level differences: i) Adding water to the beaker (sink or tray) and marking the water level. ii) Placing the crown in the beaker (sink or tray) and marking the new water level. iii) Measuring the volume difference before/after adding the crown using the graduated cylinder. OR Describes or diagrams a procedure based on displacement of water using measured overflow: i) Filling the beaker (or tray) with water ii) Placing the crown in the beaker (or tray) and collecting the overflow. iii) Measuring the volume of the overflow using the graduated cylinder.
Partial Response Describes or diagrams a partial procedure that includes displacement of water but with inadequate or no description of the steps/measurements to determine the volume.
Incorrect Response Mentions putting the crown in the beaker (sink or tray) of water with no explicit mention that the water level will rise/overflow and no or incorrect procedure given for measuring the volume.

Question 3a

Correct Response Refers to accuracy, precision, reliability, experimental uncertainty, estimation of measurement error (or similar). OR Refers only to computing an average or mean value (or median or range).
Incorrect Response Refers only to 'mistakes' or changes in the measurements (or similar); no explicit mention of accuracy, precision, experimental uncertainty, etc. OR Refers only to a 'fair test' or similar; no explicit mention of computation of average, accuracy, precision, experimental uncertainty, etc.

Task 2—continued

TIMSS 2003 problem solving and inquiry task – grade 8

Scoring guides

Question 3b

Correct Response Shows (or describes) a correct method for computing the average (mean) value. OR Shows (or describes) a correct method for determining the median value.
Incorrect Response States that it is the average, mean or median value with no or incorrect work shown. OR Shows a computation of density (mass/volume). [No detemination of average or median included.]

Question 4a

Note: To receive credit, responses must identify gold AND give an explanation based on density. Responses that identify gold with no or incorrect explanation are scored as incorrect. It is possible that a different metal or metal(s) may be identified based on an incorrect density computation in the previous question. These types of responses may be scored as correct, provided the explanation is reasonable based on the computed density.
Correct Response GOLD with an explanation based on correct density computed in previous question (19.2/cm^3).
Incorrect Response GOLD with no explanation or incorrect explanation that is NOT based on density. OR SILVER (alone or mixed). [Confuses density of crown with density of metal block.]

Question 4b

Note: To receive credit, responses must indicate that the crown is composed of a mixture of metals (alloy) AND identify the metals that might be included based on the density (crown density between the densities of pure metals). Responses that indicate that the crown is made of a mixture (alloy) or is not pure gold with no further information about what other metals are included are scored as incorrect. If responses indicate that the crown is made of Palladium (not shown in the table but with a density of 12 g/cm3), they should be scored as correct.
Correct Response Reports that the crown is made of a mixture (alloy) AND names specific metal(s) that might be included (reasonable composition based on density).
Incorrect Response Reports only that the crown is made of a mixture or is NOT pure gold (or similar); NO specific materials are named. OR Reports SILVER (density closest to 12 g/cm3). OR Reports an incorrect mixture of metals based on additive densities.

SOURCE: International Association for the Evaluation of Educational Achievement, Trends in International Mathematics and Science Study (TIMSS), 2003 Assessment.