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Physical Science

Please add ocean content under the appropriate standard

http://books.nap.edu/html/nses/

Developing Student Understanding

Item 1 **Peter Tuddenham** *Oct 22, 2004 19:54*

Developing Student Understanding

K-4

http://books.nap.edu/html/nses/6c.html#ps

During their early years, children's natural curiosity leads them to explore the world by observing and manipulating common objects and materials in their environment. Children compare, describe, and sort as they begin to form explanations of the world. Developing a subject-matter knowledge base to explain and predict the world requires many experiences over a long period. Young children bring experiences, understanding, and ideas to school; teachers provide opportunities to continue children's explorations in focused settings with other children using simple tools, such as magnifiers and measuring devices.

Full inquiry involves asking a simple question, completing an investigation, answering the question, and presenting the results to others.

Physical science in grades K-4 includes topics that give students a chance to increase their understanding of the characteristics of objects and materials that they encounter daily. Through the observation, manipulation, and classification of common objects, children reflect on the similarities and differences of the objects. As a result, their initial sketches and single-word descriptions lead to increasingly more detailed drawings and richer verbal descriptions. Describing, grouping, and sorting solid objects and materials is possible early in this grade range. By grade 4, distinctions between the properties of objects and materials can be understood in specific contexts, such as a set of rocks or living materials.

See the example entitled "Willie the Hamster"

Young children begin their study of matter by examining and qualitatively describing objects and their behavior. The important but abstract ideas of science, such as atomic structure of matter and the conservation of energy, all begin with observing and keeping track of the way the world behaves. When carefully observed, described, and measured, the properties of objects, changes in properties over time, and the changes that occur when materials interact provide the necessary precursors to the later introduction of more abstract ideas in the upper grade levels.

Students are familiar with the change of state between water and ice, but the idea of liquids having a set of properties is more nebulous and requires more instructional effort than working with solids. Most students will have difficulty with the generalization that many substances can exist as either a liquid or a solid. K-4 students do not understand that water exists as a gas when it boils or evaporates; they are more likely to think that water disappears or goes into the sky. Despite that limitation, students can conduct simple investigations with heating and evaporation that develop inquiry skills and familiarize them with the phenomena.

When students describe and manipulate objects by pushing, pulling, throwing, dropping, and rolling, they also begin to focus on the position and movement of objects: describing location as up, down, in front, or behind, and discovering the various kinds of motion and forces required to control it. By experimenting with light, heat, electricity, magnetism, and sound, students begin to understand that phenomena can be observed, measured, and controlled in various ways. The children cannot understand a complex concept such as energy. Nonetheless, they have intuitive notions of energy--for example, energy is needed to get things done; humans get energy from food. Teachers can build on the intuitive notions of students without requiring them to memorize technical definitions.

Sounds are not intuitively associated with the characteristics of their source by younger K-4 students, but that association can be developed by investigating a variety of concrete phenomena toward the end of the K-4 level. In most children's minds, electricity begins at a source and goes to a target. This mental model can be seen in students' first attempts to light a bulb using a battery and wire by attaching one wire to a bulb. Repeated activities will help students develop an idea of a circuit late in this grade range and begin to grasp the effect of more than one battery. Children cannot distinguish between heat and temperature at this age; therefore, investigating heat necessarily must focus on changes in temperature.

As children develop facility with language, their descriptions become richer and include more detail. Initially no tools need to be used, but children eventually learn that they can add to their descriptions by measuring objects--first with measuring devices they create and then by using conventional measuring instruments, such as rulers, balances, and thermometers. By recording data and making graphs and charts, older children can search for patterns and order in their work and that of their peers. For example, they can determine the speed of an object as fast, faster, or fastest in the earliest grades. As students get older, they can represent motion on simple grids and graphs and describe speed as the distance traveled in a given unit of time.

5-8

http://books.nap.edu/html/nses/6d.html#ps

In grades 5-8, the focus on student understanding shifts from properties of objects and materials to the characteristic properties of the substances from which the materials are made. In the K-4 years, students learned that objects and materials can be sorted and ordered in terms of their properties. During that process, they learned that some properties, such as size, weight, and shape, can be assigned only to the object while other properties, such as color, texture, and hardness, describe the materials from which objects are made. In grades 5-8, students observe and measure characteristic properties, such as boiling points, melting points, solubility, and simple chemical changes of pure substances and use those properties to distinguish and separate one substance from another.

Students usually bring some vocabulary and primitive notions of atomicity to the science class but often lack understanding of the evidence and the logical arguments that support the particulate model of matter. Their early ideas are that the particles have the same properties as the parent material; that is, they are a tiny piece of the substance. It can be tempting to introduce atoms and molecules or improve students' understanding of them so that particles can be used as an explanation for the properties of elements and compounds. However, use of such terminology is premature for these students and can distract from the understanding that can be gained from focusing on the observation and description of macroscopic features of substances and of physical and chemical reactions. At this level, elements and compounds can be defined operationally from their chemical characteristics, but few students can comprehend the idea of atomic and molecular particles.

In grades 5-8, students observe and measure characteristic properties, such as boiling and melting points, solubility, and simple chemical changes of pure substances, and use those properties to distinguish and separate one substance from another.

The study of motions and the forces causing motion provide concrete experiences on which a more comprehensive understanding of force can be based in grades 9-12. By using simple objects, such as rolling balls and mechanical toys, students can move from qualitative to quantitative descriptions of moving objects and begin to describe the forces acting on the objects. Students' everyday experience is that friction causes all moving objects to slow down and stop. Through experiences in which friction is reduced, students can begin to see that a moving object with no friction would continue to move indefinitely, but most students believe that the force is still acting if the object is moving or that it is "used up" if the motion stops. Students also think that friction, not inertia, is the principle reason objects remain at rest or require a force to move. Students in grades 5-8 associate force with motion and have difficulty understanding balanced forces in equilibrium, especially if the force is associated with static, inanimate objects, such as a book resting on the desk.

See the example entitled "Funny Water"

The understanding of energy in grades 5-8 will build on the K-4 experiences with light, heat, sound, electricity, magnetism, and the motion of objects. In 5-8, students begin to see the connections among those phenomena and to become familiar with the idea that energy is an important property of substances and that most change involves energy transfer. Students might have some of the same views of energy as they do of force--that it is associated with animate objects and is linked to motion. In addition, students view energy as a fuel or something that is stored, ready to use, and gets used up. The intent at this level is for students to improve their understanding of energy by experiencing many kinds of energy transfer.

9-12

http://books.nap.edu/html/nses/6e.html#ps

High-school students develop the ability to relate the macroscopic properties of substances that they study in grades K-8 to the microscopic structure of substances. This development in understanding requires students to move among three domains of thought--the macroscopic world of observable phenomena, the microscopic world of molecules, atoms, and subatomic particles, and the symbolic and mathematical world of chemical formulas, equations, and symbols.

The relationship between properties of matter and its structure continues as a major component of study in 9-12 physical science. In the elementary grades, students studied the properties of matter and the classification of substances using easily observable properties. In the middle grades, they examined change of state, solutions, and simple chemical reactions, and developed enough knowledge and experience to define the properties of elements and compounds. When students observe and integrate a wide variety of evidence, such as seeing copper "dissolved" by an acid into a solution and then retrieved as pure copper when it is displaced by zinc, the idea that copper atoms are the same for any copper object begins to make sense. In each of these reactions, the knowledge that the mass of the substance does not change can be interpreted by assuming that the number of particles does not change during their rearrangement in the reaction. Studies of student understanding of molecules indicate that it will be difficult for them to comprehend the very small size and large number of particles involved. The connection between the particles and the chemical formulas that represent them is also often not clear.

It is logical for students to begin asking about the internal structure of atoms, and it will be difficult, but important, for them to know "how we know." Quality learning and the spirit and practice of scientific inquiry are lost when the evidence and argument for atomic structure are replaced by direct assertions by the teacher and text. Although many experiments are difficult to replicate in school, students can read some of the actual reports and examine the chain of evidence that led to the development of the current concept of the atom. The nature of the atom is far from totally understood; scientists continue to investigate atoms and have discovered even smaller constituents of which neutrons and protons are made.

Laboratory investigation of the properties of substances and their changes through a range of chemical interactions provide a basis for the high school graduate to understand a variety of reaction types and their applications, such as the capability to liberate elements from ore, create new drugs, manipulate the structure of genes, and synthesize polymers.

Understanding of the microstructure of matter can be supported by laboratory experiences with the macroscopic and microscopic world of forces, motion (including vibrations and waves), light, and electricity. These experiences expand upon the ones that the students had in the middle school and provide new ways of understanding the movement of muscles, the transport of materials across cell membranes, the behavior of atoms and molecules, communication technologies, and the movement of planets and galaxies. By this age, the concept of a force is better understood, but static forces in equilibrium and students' intuitive ideas about forces on projectiles and satellites still resist change through instruction for a large percentage of the students.

On the basis of their experiences with energy transfers in the middle grades, high-school students can investigate energy transfers quantitatively by measuring variables such as temperature change and kinetic energy. Laboratory investigations and descriptions of other experiments can help students understand the evidence that leads to the conclusion that energy is conserved. Although the operational distinction between temperature and heat can be fairly well understood after careful instruction, research with high-school students indicates that the idea that heat is the energy of random motion and vibrating molecules is difficult for students to understand.

9-12 Structure of atoms

Item 2 **Peter Tuddenham** *Oct 22, 2004 19:55*

9-12 Structure of atoms

Response 2:1 **Patricia DuBose** *Oct 27, 2004 15:49*

Review the structure as I discuss the unusal properties of water... electron, proton, neutron, valence (why there are 2 H and one O)... bonding and solubility (water as the universal solvent)

Response 2:2 **Gene Williamson** *Oct 27, 2004 18:08*

changes in water chemistry brought about by hydrothermal venting

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Response 2:3 **Patricia DuBose** *Oct 28, 2004 15:02*

we do water quality testing at our local beach for nitrates, phosphates, copper, pH...

5-8 Properties and changes of properties in matter

Item 3 **Peter Tuddenham** *Oct 22, 2004 19:55*

5-8 Properties and changes of properties in matter

Response 3:1 **Susan Snyder** *Oct 27, 2004 10:38*

Content topics: 1) An important property of water is that it absorbs and releases heat more slowly than soil. Because of this property, oceans and large lakes modify the temperature of surrounding regions. (eg. regions along coasts are warmer in the winter and cooler in the summer than more inland regions.) 2) Important chemicals and compounds (eg. carbon, water, and nitrogen) cycle among the ocean, atmosphere, and land.

Response 3:2 **Gabrielle Johnson** *Oct 27, 2004 13:59*

Buoyancy could be introduced here with respect to pelagic organisms. I have my 5th grade make plankton model with the goal to have it sink slowly. WE then go back and look at pictures and plankton. They see that the ones that sank the slowest look really similar to the plankton: spines, etc.

Response 3:3 **Stacey Halboth** *Oct 28, 2004 23:43*

Curriculum that supports the pelagic organisms with understanding of plankton is "The Great Plankton Race"-MARE activity for fifth grade.

Response 3:4 **Lynn Whitley** *Oct 29, 2004 01:15*

Other properties of water: 1) poor conductor of elecricity, 2) good solvent. 3) it's unique freezing properties, ice floats thereby allowing live organisms to survive during winter. This may be a bit more fresh water based, but can link into watersheds and the larger picture.

K-4 Properties of objects and materials

Item 4 **Peter Tuddenham** *Oct 22, 2004 19:56*

K-4 Properties of objects and materials

Response 4:1 **Pam Stryker** *Oct 26, 2004 14:08*

Early elementary is all about identifying and describing the properties of objects and materials. It is also the properties of these materials that define the define the habitat that the organisms live in. Students in the early years need to explore the differences between liquids such as salt water, fresh water and oil. They need to discover that materials may be dissolved and then recovered - salt. They need to explore the properties of sand, soil, and rocks. Messing with and observing what happens with these materials when they interact with other materials such as water help to develop the underlying concepts relating to estuaries, shorelines, etc. The properties of these materials also set the stage for understanding the adaptations for animals to survive living on or near these. Textbooks too often introduce vocabulary in their expository text that the student has no experience with. This leads to memorization not true literacy. At an early level, we need to introduce a smaller focus with more depth, looking at all that interacts within that focus. Not the ocean, but a beach. Each grade level needs to build one on another. The big concepts: systems, adaptation, change, etc. must drive what is taught...not factoids. That way we are teaching students to look at the overall picture to make more insightful decisions.

Response 4:2 **Gabrielle Johnson** *Oct 27, 2004 13:52*

I jsut want to add to Pam's sink or float characteristics.

Response 4:3 **Gabrielle Johnson** *Oct 27, 2004 13:53*

I jsut want to add to Pam's sink or float characteristics.

Response 4:4 **Francesca Cava, Nat. Geo. Society, Santa Barbara, California** *Oct 28, 2004 10:39*

Characteristics of the oceans and ocean ecosystems and ocean habitats (ie, temperature, the difference in salty and fresh water, etc)
Also, the similarities and differences amoung the Earth's oceans (ie, cold water in the Pacific vs warmer waters of the East coast and Florida, difference in sizes of oceans, differences in what lives in various oceans, etc.)

Response 4:5 **Rita Bell** *Oct 29, 2004 16:00*

Properties of objects -- ocean topics

salt vs. fresh water; warm vs. cold water; floating and sinking; sorting shells, seastars, sock-puppet eels, sand samples
measuring, weighing, taking temperatures

Materials can exist in different states
Water evaporates -- related to the rocky shore and animals being exposed at low tide.
Water cycle
Icebergs

Response 4:6 **Bob Stewart** *Oct 30, 2004 14:28*

I would add evaporation and condensation. Where does the water come from that appears on the outside of a glass of ice water?

Where does the water go when a pan of water sits out in the classroom for a few days?

Response 4:7 **Gabrielle Johnson** *Oct 30, 2004 19:32*

Alginate beads would also be an interesting one

9-12 Structure and properties of matter

Item 5 **Peter Tuddenham** *Oct 22, 2004 19:56*

9-12 Structure and properties of matter

Response 5:1 **Patricia DuBose** *Oct 27, 2004 15:51*

Using the unusual nature of the water molecule... phases of water phase change = physical change... density... solubility...

Response 5:2 **Erika McPhee-Shaw** *Oct 28, 2004 14:35*

Mass and density are important concepts in physics, chemistry, and biology, and and oceanographic/earth science context lends itself very well to learning this subject.

When I taught marine science to junior high students, I would always start out with this simplified example of how the mass in the world is organized by gravitational sorting. The earth's core is made of iron - it is one of the "heaviest" (high density) elements common in our planet. Therefore it is found at the center, where gravity has "pulled it in with time." As you go outward from the core, there are more "lighter" elements, such as silica. Silica is found in greater proportion in the continental crust than in either mantle material or oceanic crusts. Thus, continents kind of "float" in the mantle material, and that's why the land and mountains are high while the oceans have filled up the deep basins. Water's density of ~ 1000 kg/m3 is substantially lighter than rocks (~3000 kg/m3 (? I think?), so water is the next "layer" on the planet (filling the deep basins or low spots), and then the atmosphere is the next layer. The atmosphere gets thinner as you go up towards space... molecules are getting farther apart and thus the density goes down. Gravity pulls less on air than on denser substances.

I think this kind of conceptual model is a fun way to discuss density, and then from that to move on to the important concept of gravitational force and how it acts on mass.... so maybe I'll move over the forces and energy section now......

Response 5:3 **Patricia DuBose** *Oct 28, 2004 15:54*

Excellent sequencing Erika!!!! I am definately going to use this model!

I do an activity with basalt and granite and have the students calculate the density and then calculate their percent error... this then leads into the why the continents are higher on the mantle than the ocean floor...

Response 5:4 **Gene Williamson** *Oct 28, 2004 16:31*

Just a thought re 5-2, 5-3: Specific gravity is easier to compute (ratio with no units) and kids get better results because they are a lot better at measuring mass than volume.

5-8 Motions and forces

Item 6 **Peter Tuddenham** *Oct 22, 2004 19:58*

5-8 Motions and forces

Response 6:1 **Susan Snyder** *Oct 27, 2004 11:04*

Content topics: Several different forces produce motion within the ocean: Winds blowing on the ocean's surface, create surface waves. Tsunami waves are generated by sudden seismic activity in earth's crust. Tides result from gravitational attraction within the moon-earth-sun system. Surface currents are affected by global winds and Coriolis force. Deep water currents are created as a result of water density differences.

Response 6:2 **Gene Williamson** *Oct 27, 2004 18:03*

All of the above influence the distribution of life. Also thermocline, halocline, pycnocline-how they form, why they are important.

Response 6:3 **Bob Stewart** *Oct 28, 2004 20:02*

A few general comments: 1) All currents currents below the thin Ekman layer are generated by density differences, which set up pressure gradients. 2) The deep, abysal circulation is driven by mixing in the ocean, sinking of cold water cannot drive the circulation in the long run.

Response 6:4 **Stacey Halboth** *Oct 28, 2004 23:50*

Curriculum that helps to explain global winds/coriolis force/waves/deep water currents as a result of water temperature and how all of these forces have an effect on our planet is through an activity called "Waste Disposal" GEM Lawrence Hall of Science. This can be taught at 5-8.

K-4 Position, and motion of objects

Item 7 **Peter Tuddenham** *Oct 22, 2004 19:58*

K-4 Position, and motion of objects

Response 7:1 **Gabrielle Johnson** *Oct 27, 2004 13:54*

Wave action could work for this, look at how the waves shape the beach and what happens with jetties or sea walls to the shape of the beach.

Response 7:2 **Francesca Cava, Nat. Geo. Society, Santa Barbara, California** *Oct 28, 2004 10:41*

Location of major oceans, seas and gulfs. Location of rivers, estuaries. Location of nearby bodies of water and the introduction of the watershed concept.

Response 7:3 **Francesca Cava, Nat. Geo. Society, Santa Barbara, California** *Oct 28, 2004 10:41*

The concepts of tides and currents.

Response 7:4 **Rita Bell** *Oct 29, 2004 16:06*

Relative position and measuring its position over time -- ocean topics
moving waves, objects moving in the water, water level at high and low tides (dishpan tidepool activity)

Push or pull -- ocean topics
Making waves
Waves moving sand on a model beach

Response 7:5 **Pam Stryker** *Oct 29, 2004 19:13*

This could also relate to the motion of the organisms in the fluid environment. Jellyfish...fish fins....scallops

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9-12 Chemical reactions

Item 8 **Peter Tuddenham** *Oct 22, 2004 19:59*

9-12 Chemical reactions

Response 8:1 **Gabrielle Johnson** *Oct 27, 2004 14:00*

chemiluminescence as an analogy to bioluminescence. I demo this in 5th grade as a discussion of bioluminescence, however in the upper grades the students should be able to understand the chemistry.

Response 8:2 **Patricia DuBose** *Oct 27, 2004 15:52*

as well as photosynthesis, respiration and chemosynthesis... all key processes in the ocean!

nitrogen cycle is a good place to do reactions as the nitrites are converted to nitrates, etc.

Response 8:3 **Gabrielle Johnson** *Oct 28, 2004 12:49*

One could also included calcification found in marine organisms such a corals, algae and coccolithophorids

chemosynthesis (as Patricia stated) could also be tied to evolutionary processes

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Response 8:4 **Erika McPhee-Shaw** *Oct 28, 2004 14:54*

Students learning about pH could be exposed to the carbon cycle in oceans. It's pretty complex, but understanding just some of it goes a long way to helping students understand how the climate change scientists look at how carbon and carbon dioxide move around the planet and over what time scales.

5-8 Transfer of energy

Item 9 **Peter Tuddenham** *Oct 22, 2004 19:59*

5-8 Transfer of energy

Response 9:1 **Gabrielle Johnson** *Oct 27, 2004 14:01*

Wave action and its influenc on beach structure.
Erosion events.
Heat transfer

Response 9:2 **Stacey Halboth** *Oct 28, 2004 23:45*

Evaporation (water cycle) with the awareness of how much the ocean plays a roll in this process.

K-4 Light, heat, electricity, and magnetism

Item 10 **Peter Tuddenham** *Oct 22, 2004 19:59*

K-4 Light, heat, electricity, and magnetism

Response 10:1 **Gabrielle Johnson** *Oct 27, 2004 13:55*

Examining light underwater comparative to the terrestrial world. Conductivity related to salt. Introduction of compasses and ocean navigation

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Response 10:2 **Francesca Cava, Nat. Geo. Society, Santa Barbara, California** *Oct 28, 2004 10:42*

The concept of bioluminescence (from fireflies to sparkles in the waves)

Response 10:3 **Bob Stewart** *Oct 30, 2004 14:30*

sunlight supplies heat and warms water. Earth is warm only because of the sun.

Infrared, heat can be carried by invisible rays, but we can feel the rays even if we can't see them. Hold your hand over a hot object.

9-12 Conservation of energy and increase in disorder

Item 11 **Peter Tuddenham** *Oct 22, 2004 20:00*

9-12 Conservation of energy and increase in disorder

Response 11:1 **Patricia DuBose** *Oct 27, 2004 15:56*

food web activities... energy lost from the food web as heat... preying... mating... etc

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Response 11:2 **Erika McPhee-Shaw** *Oct 28, 2004 14:49*

In the context of physics and chemistry, there are many ways ocean examples can be used to teach this subject. Heating of water and air can be used to explain thermodynamics, heat, and gas-law type relationships between Temperature - Pressure -Volume(mass and density). Then the vertical motions that ensue due to changes in buoyancy caused by heating or cooling convert heat energy to kinetic energy, or motion. This kinetic energy is manifest as winds in the atmosphere, and currents and circulation in the ocean. The heat exchange between the ocean and atmosphere during hurricanes would provide a good example; complex but at least something that can be gotten through in a high school physics class.

Response 11:3 **Patricia DuBose** *Oct 28, 2004 16:06*

pressures can also be explained as the form/function of the deep ocean creatures... the pictures and examples of the styrofoam cups that go to the bottom and return as little tiny cups!!!

9-12 Interactions of energy and matter

Item 12 **Peter Tuddenham** *Oct 22, 2004 20:00*

9-12 Interactions of energy and matter

K-12 Other topics

Item 13 **Peter Tuddenham** *Oct 22, 2004 20:00*

K-12 Other topics
