Standard 4—Science
Elementary

Physical Setting

1. The Earth and celestial phenomena can be described by principles of relative motion and perspective.

Students:
- **describe patterns of daily, monthly, and seasonal changes in their environment.**

This is evident, for example, when students:

▲ conduct a long-term weather investigation, such as running a weather station or collecting weather data.
▲ keep a journal of the phases of the moon over a one-month period. This information is collected for several different one-month periods and compared.

2. Many of the phenomena that we observe on Earth involve interactions among components of air, water, and land.

Students:
- **describe the relationships among air, water, and land on Earth.**

This is evident, for example, when students:

▲ observe a puddle of water outdoors after a rainstorm. On a return visit after the puddle has disappeared, students describe where the water came from and possible locations for it now.
▲ assemble rock and mineral collections based on characteristics such as erosional features or crystal size features.

Key ideas are identified by numbers (1).
Performance indicators are identified by bullets (•).
Sample tasks are identified by triangles (▲).

3. Matter is made up of particles whose properties determine the observable characteristics of matter and its reactivity.

Students:
- **observe and describe properties of materials using appropriate tools.**
- **describe chemical and physical changes, including changes in states of matter.**

This is evident, for example, when students:

▲ compare the appearance of materials when seen with and without the aid of a magnifying glass.
▲ investigate simple physical and chemical reactions and the chemistry of household products, e.g., freezing, melting, and evaporating; a comparison of new and rusty nails; the role of baking soda in cooking.

4. Energy exists in many forms, and when these forms change energy is conserved.

Students:
- **describe a variety of forms of energy (e.g., heat, chemical, light) and the changes that occur in objects when they interact with those forms of energy.**
- **observe the way one form of energy can be transformed into another form of energy present in common situations (e.g., mechanical to heat energy, mechanical to electrical energy, chemical to heat energy).**

This is evident, for example, when students:

▲ investigate the interactions of liquids and powders that result in chemical reactions (e.g., vinegar and baking soda) compared to interactions that do not (e.g., water and sugar).
▲ in order to demonstrate the transformation of chemical to electrical energy, construct electrical cells from objects, such as lemons or potatoes, using pennies and aluminum foil inserted in slits at each end of fruits or vegetables; the penny and aluminum are attached by wires to a milliammeter. Students can compare the success of a variety of these electrical cells.

5. Energy and matter interact through forces that result in changes in motion.

Students:
- **describe the effects of common forces (pushes and pulls) on objects, such as those caused by gravity, magnetism, and mechanical forces.**
- **describe how forces can operate across distances.**

This is evident, for example, when students:

▲ investigate simple machines and use them to perform tasks.

Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science.

The Living Environment

1. Living things are both similar to and different from each other and nonliving things.

Students:

- **describe the characteristics of and variations between living and nonliving things.**
- **describe the life processes common to all living things.**

This is evident, for example, when students:

▲ grow a plant or observe a pet, investigating what it requires to stay alive, including evaluating the relative importance and necessity of each item.

▲ investigate differences in personal body characteristics, such as temperature, pulse, heart rate, blood pressure, and reaction time.

2. Organisms inherit genetic information in a variety of ways that result in continuity of structure and function between parents and offspring.

Students:

- **recognize that traits of living things are both inherited and acquired or learned.**
- **recognize that for humans and other living things there is genetic continuity between generations.**

This is evident, for example, when students:

▲ interact with a classroom pet, observe its behaviors, and record what they are able to teach the animal, such as navigation of a maze or performance of tricks, compared to that which remains constant, such as eye color, or number of digits on an appendage.

▲ use breeding records and photographs of racing horses or pedigreed animals to recognize that variations exist from generation to generation but "like begets like."

3. Individual organisms and species change over time.

Students:

- **describe how the structures of plants and animals complement the environment of the plant or animal.**
- **observe that differences within a species may give individuals an advantage in surviving and reproducing.**

This is evident, for example, when students:

▲ relate physical characteristics of organisms to habitat characteristics (e.g., long hair and fur color change for mammals living in cold climates).

▲ visit a farm or a zoo and make a written or pictorial comparison of members of a litter and identify characteristics that may provide an advantage.

4. The continuity of life is sustained through reproduction and development.

Students:

- **describe the major stages in the life cycles of selected plants and animals.**
- **describe evidence of growth, repair, and maintenance, such as nails, hair, and bone, and the healing of cuts and bruises.**

This is evident, for example, when students:

▲ grow bean plants or butterflies; record and describe stages of development.

5. Organisms maintain a dynamic equilibrium that sustains life.

Students:

- **describe basic life functions of common living specimens (guppy, mealworm, gerbil).**
- **describe some survival behaviors of common living specimens.**
- **describe the factors that help promote good health and growth in humans.**

This is evident, for example, when students:

▲ observe a single organism over a period of weeks and describe such life functions as moving, eating, resting, and eliminating.

▲ observe and demonstrate reflexes such as pupil dilation and contraction and relate such reflexes to improved survival.

▲ analyze the extent to which diet and exercise habits meet cardiovascular, energy, and nutrient requirements.

6. Plants and animals depend on each other and their physical environment.

Students:

- **describe how plants and animals, including humans, depend upon each other and the nonliving environment.**
- **describe the relationship of the sun as an energy source for living and nonliving cycles.**

This is evident, for example, when students:

▲ investigate how humans depend on their environment (neighborhood), by observing, recording, and discussing the interactions that occur in carrying out their everyday lives.

▲ observe the effects of sunlight on growth for a garden vegetable.

7. Human decisions and activities have had a profound impact on the physical and living environment.

Students:

- **identify ways in which humans have changed their environment and the effects of those changes.**

This is evident, for example, when students:

▲ give examples of how inventions and innovations have changed the environment; describe benefits and burdens of those changes.

Standard 4—Science
Intermediate

Physical Setting

1. The Earth and celestial phenomena can be described by principles of relative motion and perspective.

Students:
- **explain daily, monthly, and seasonal changes on earth.**

This is evident, for example, when students:
- ▲ create models, drawings, or demonstrations describing the arrangement, interaction, and movement of the Earth, moon, and sun.
- ▲ plan and conduct an investigation of the night sky to describe the arrangement, interaction, and movement of celestial bodies.

2. Many of the phenomena that we observe on Earth involve interactions among components of air, water, and land.

Students:
- **explain how the atmosphere (air), hydrosphere (water), and lithosphere (land) interact, evolve, and change.**
- **describe volcano and earthquake patterns, the rock cycle, and weather and climate changes.**

This is evident, for example, when students:
- ▲ add heat to and subtract heat from water and graph the temperature changes, including the resulting phase changes.
- ▲ make a record of reported earthquakes and volcanoes and interpret the patterns formed worldwide.

3. Matter is made up of particles whose properties determine the observable characteristics of matter and its reactivity.

Students:
- **observe and describe properties of materials, such as density, conductivity, and solubility.**
- **distinguish between chemical and physical changes.**
- **develop their own mental models to explain common chemical reactions and changes in states of matter.**

This is evident, for example, when students:
- ▲ test and compare the properties (hardness, shape, color, etc.) of an array of materials.
- ▲ observe an ice cube as it begins to melt at temperature and construct an explanation for what happens, including sketches and written descriptions of their ideas.

4. Energy exists in many forms, and when these forms change energy is conserved.

Students:
- **describe the sources and identify the transformations of energy observed in everyday life.**
- **observe and describe heating and cooling events.**
- **observe and describe energy changes as related to chemical reactions.**
- **observe and describe the properties of sound, light, magnetism, and electricity.**
- **describe situations that support the principle of conservation of energy.**

This is evident, for example, when students:
- ▲ design and construct devices to transform/transfer energy.
- ▲ conduct supervised explorations of chemical reactions (not including ammonia and bleach products) for selected household products, such as hot and cold packs used to treat sport injuries.
- ▲ build an electromagnet and investigate the effects of using different types of core materials, varying thicknesses of wire, and different circuit types.

5. Energy and matter interact through forces that result in changes in motion.

Students:
- **describe different patterns of motion of objects.**
- **observe, describe, and compare effects of forces (gravity, electric current, and magnetism) on the motion of objects.**

This is evident, for example, when students:
- ▲ investigate physics in everyday life, such as at an amusement park or a playground.
- ▲ use simple machines made of pulleys and levers to lift objects and describe how each machine transforms the force applied to it.
- ▲ build “Rube Goldberg” type devices and describe the energy transformations evident in them.

Key ideas are identified by numbers (1).
Performance indicators are identified by bullets (•).
Sample tasks are identified by triangles (▲).

Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science.

The Living Environment

1. Living things are both similar to and different from each other and nonliving things.

Students:
- **compare and contrast the parts of plants, animals, and one-celled organisms.**
- **explain the functioning of the major human organ systems and their interactions.**

This is evident, for example, when students:

▲ conduct a survey of the school grounds and develop appropriate classification keys to group plants and animals by shared characteristics.

▲ use spring-type clothespins to investigate muscle fatigue or rulers to determine the effect of amount of sleep on hand-eye coordination.

2. Organisms inherit genetic information in a variety of ways that result in continuity of structure and function between parents and offspring.

Students:
- **describe sexual and asexual mechanisms for passing genetic materials from generation to generation.**
- **describe simple mechanisms related to the inheritance of some physical traits in offspring.**

This is evident, for example, when students:

▲ contrast dominance and blending as models for explaining inheritance of traits.

▲ trace patterns of inheritance for selected human traits.

3. Individual organisms and species change over time.

Students:
- **describe sources of variation in organisms and their structures and relate the variations to survival.**
- **describe factors responsible for competition within species and the significance of that competition.**

This is evident, for example, when students:

▲ conduct a long-term investigation of plant or animal communities.

▲ investigate the acquired effects of industrialization on tree trunk color and those effects on different insect species.

4. The continuity of life is sustained through reproduction and development.

Students:
- **observe and describe the variations in reproductive patterns of organisms, including asexual and sexual reproduction.**
- **explain the role of sperm and egg cells in sexual reproduction.**
- **observe and describe developmental patterns in selected plants and animals (e.g., insects, frogs, humans, seed-bearing plants).**
- **observe and describe cell division at the microscopic level and its macroscopic effects.**

This is evident, for example, when students:

▲ apply a model of the genetic code as an analogue for the role of the genetic code in human populations.

5. Organisms maintain a dynamic equilibrium that sustains life.

Students:
- **compare the way a variety of living specimens carry out basic life functions and maintain dynamic equilibrium.**
- **describe the importance of major nutrients, vitamins, and minerals in maintaining health and promoting growth and explain the need for a constant input of energy for living organisms.**

This is evident, for example, when students:

▲ record and compare the behaviors of animals in their natural habitats and relate how these behaviors are important to the animals.

▲ design and conduct a survey of personal nutrition and exercise habits, and analyze and critique the results of that survey.

6. Plants and animals depend on each other and their physical environment.

Students:
- **describe the flow of energy and matter through food chains and food webs.**
- **provide evidence that green plants make food and explain the significance of this process to other organisms.**

This is evident, for example, when students:

▲ construct a food web for a community of organisms and explore how elimination of a particular part of a chain affects the rest of the chain and web.

7. Human decisions and activities have had a profound impact on the physical and living environment.

Students:
- **describe how living things, including humans, depend upon the living and nonliving environment for their survival.**
- **describe the effects of environmental changes on humans and other populations.**

This is evident, for example, when students:

▲ conduct an extended investigation of a local environment affected by human actions, (e.g., a pond, stream, forest, empty lot).

Standard 4—Science
Commencement

Physical Setting

1. The Earth and celestial phenomena can be described by principles of relative motion and perspective.

Students:
- **explain complex phenomena, such as tides, variations in day length, solar insolation, apparent motion of the planets, and annual traverse of the constellations.**
- **describe current theories about the origin of the universe and solar system.**

This is evident, for example, when students:

▲ create models, drawings, or demonstrations to explain changes in day length, solar insolation, and the apparent motion of planets.

2. Many of the phenomena that we observe on Earth involve interactions among components of air, water, and land.

Students:
- **use the concepts of density and heat energy to explain observations of weather patterns, seasonal changes, and the movements of the Earth's plates.**
- **explain how incoming solar radiations, ocean currents, and land masses affect weather and climate.**

This is evident, for example, when students:

▲ use diagrams of ocean currents at different latitudes to develop explanations for the patterns present.

3. Matter is made up of particles whose properties determine the observable characteristics of matter and its reactivity.

Students:
- **explain the properties of materials in terms of the arrangement and properties of the atoms that compose them.**
- **use atomic and molecular models to explain common chemical reactions.**
- **apply the principle of conservation of mass to chemical reactions.**
- **use kinetic molecular theory to explain rates of reactions and the relationships among temperature, pressure, and volume of a substance.**

This is evident, for example, when students:

▲ use the atomic theory of elements to justify their choice of an element for use as a lighter than air gas for a launch vehicle.

▲ represent common chemical reactions using three-dimensional models of the molecules involved.

▲ discuss and explain a variety of everyday phenomena involving rates of chemical reactions, in terms of the kinetic molecular theory (e.g., use of refrigeration to keep food from spoiling, ripening of fruit in a bowl, use of kindling wood to start a fire, different types of flames that come from a Bunsen burner).

4. Energy exists in many forms, and when these forms change energy is conserved.

Students:
- **observe and describe transmission of various forms of energy.**
- **explain heat in terms of kinetic molecular theory.**
- **explain variations in wavelength and frequency in terms of the source of the vibrations that produce them, e.g., molecules, electrons, and nuclear particles.**
- **explain the uses and hazards of radioactivity.**

This is evident, for example, when students:

▲ demonstrate through drawings, models, and diagrams how the potential energy that exists in the chemical bonds of fossil fuels can be converted to electrical energy in a power plant (potential energy ⇨ heat energy ⇨ mechanical energy ⇨ electrical energy).

▲ investigate the sources of radioactive emissions in their environment and the dangers and benefits they pose for humans.

5. Energy and matter interact through forces that result in changes in motion.

Students:
- **explain and predict different patterns of motion of objects (e.g., linear and angular motion, velocity and acceleration, momentum and inertia).**
- **explain chemical bonding in terms of the motion of electrons.**
- **compare energy relationships within an atom's nucleus to those outside the nucleus.**

This is evident, for example, when students:

▲ construct drawings, models, and diagrams representing several different types of chemical bonds to demonstrate the basis of the bond, the strength of the bond, and the type of electrical attraction that exists.

Key ideas are identified by numbers (1).
Performance indicators are identified by bullets (•).
Sample tasks are identified by triangles (▲).

Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science.

The Living Environment

1. Living things are both similar to and different from each other and nonliving things.

Students:

- **explain how diversity of populations within ecosystems relates to the stability of ecosystems.**
- **describe and explain the structures and functions of the human body at different organizational levels (e.g., systems, tissues, cells, organelles).**
- **explain how a one-celled organism is able to function despite lacking the levels of organization present in more complex organisms.**

2. Organisms inherit genetic information in a variety of ways that result in continuity of structure and function between parents and offspring.

Students:

- **explain how the structure and replication of genetic material result in offspring that resemble their parents.**
- **explain how the technology of genetic engineering allows humans to alter the genetic makeup of organisms.**

This is evident, for example, when students:

▲ record outward characteristics of fruit flies and then breed them to determine patterns of inheritance.

3. Individual organisms and species change over time.

Students:

- **explain the mechanisms and patterns of evolution.**

This is evident, for example, when students:

▲ determine characteristics of the environment that affect a hypothetical organism and explore how different characteristics of the species give it a selective advantage.

4. The continuity of life is sustained through reproduction and development.

Students:

- **explain how organisms, including humans, reproduce their own kind.**

This is evident, for example, when students:

▲ observe the development of fruit flies or rapidly maturing plants, from fertilized egg to mature adult, relating embryological development and structural adaptations to the propagation of the species.

5. Organisms maintain a dynamic equilibrium that sustains life.

Students:

- **explain the basic biochemical processes in living organisms and their importance in maintaining dynamic equilibrium.**
- **explain disease as a failure of homeostasis.**
- **relate processes at the system level to the cellular level in order to explain dynamic equilibrium in multicelled organisms.**

This is evident, for example, when students:

▲ investigate the biochemical processes of the immune system, and its relationship to maintaining mental and physical health.

6. Plants and animals depend on each other and their physical environment.

Students:

- **explain factors that limit growth of individuals and populations.**
- **explain the importance of preserving diversity of species and habitats.**
- **explain how the living and nonliving environments change over time and respond to disturbances.**

This is evident, for example, when students:

▲ conduct a long-term investigation of a local ecosystem.

7. Human decisions and activities have had a profound impact on the physical and living environment.

Students:

- **describe the range of interrelationships of humans with the living and nonliving environment.**
- **explain the impact of technological development and growth in the human population on the living and non-living environment.**
- **explain how individual choices and societal actions can contribute to improving the environment.**

This is evident, for example, when students:

▲ compile a case study of a technological development that has had a significant impact on the environment.

Standard 5—Technology

Elementary

Engineering Design

1. Engineering design is an iterative process involving *modeling* and *optimization* used to develop technological solutions to problems within given constraints.

Students:

- **describe objects, imaginary or real, that might be modeled or made differently and suggest ways in which the objects can be changed, fixed, or improved.**
- **investigate prior solutions and ideas from books, magazines, family, friends, neighbors, and community members.**
- **generate ideas for possible solutions, individually and through group activity; apply age-appropriate mathematics and science skills; evaluate the ideas and determine the best solution; and explain reasons for the choices.**
- **plan and build, under supervision, a model of the solution using familiar materials, processes, and hand tools.**
- **discuss how best to test the solution; perform the test under teacher supervision; record and portray results through numerical and graphic means; discuss orally why things worked or didn't work; and summarize results in writing, suggesting ways to make the solution better.**

This is evident, for example, when students:

▲ read a story called *Humpty's Big Day* wherein the readers visit the place where Humpty Dumpty had his accident, and are asked to design and model a way to get to the top of the wall and down again safely.

▲ generate and draw ideas for a space station that includes a pleasant living and working environment.

▲ design and model footwear that they could use to walk on a cold, sandy surface.

Tools, Resources, and Technological Processes

2. Technological tools, materials, and other resources should be selected on the basis of safety, cost, availability, appropriateness, and environmental impact; technological processes change energy, information, and material resources into more useful forms.

Students:

- **explore, use, and process a variety of materials and energy sources to design and construct things.**
- **understand the importance of safety, cost, ease of use, and availability in selecting tools and resources for a specific purpose.**
- **develop basic skill in the use of hand tools.**
- **use simple manufacturing processes (e.g., assembly, multiple stages of production, quality control) to produce a product.**
- **use appropriate graphic and electronic tools and techniques to process information.**

This is evident, for example, when students:

▲ explore and use materials, joining them with the use of adhesives and mechanical fasteners to make a cardboard marionette with moving parts.

▲ explore materials and use forming processes to heat and bend plastic into a shape that can hold napkins.

▲ explore energy sources by making a simple motor that uses electrical energy to produce continuous mechanical motion.

▲ develop skill with a variety of hand tools and use them to make or fix things.

▲ process information electronically such as using a video system to advertise a product or service.

▲ process information graphically such as taking photos and developing and printing the pictures.

Key ideas are identified by numbers (1).
Performance indicators are identified by bullets (•).
Sample tasks are identified by triangles (▲).

Students will apply technological knowledge and skills to design, construct, use, and evaluate products and systems to satisfy human and environmental needs.

Computer Technology

3. Computers, as tools for design, modeling, information processing, communication, and system control, have greatly increased human productivity and knowledge.

Students:

- **identify and describe the function of the major components of a computer system.**
- **use the computer as a tool for generating and drawing ideas.**
- **control computerized devices and systems through programming.**
- **model and simulate the design of a complex environment by giving direct commands.**

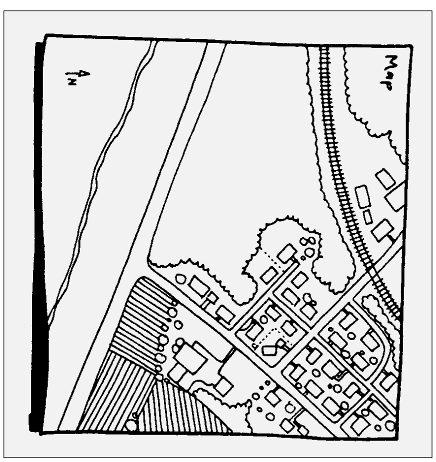
This is evident, for example, when students:

▲ control the operation of a toy or household appliance by programming it to perform a task.

▲ execute a computer program, such as SimCity, Theme Park, or The Factory to model and simulate an environment.

▲ model and simulate a system using construction modeling software, such as The Incredible Machine.

Sample Problem/Activity



Computer design for model community

Technological Systems

4. Technological systems are designed to achieve specific results and produce outputs, such as products, structures, services, energy, or other systems.

Students:

- **identify familiar examples of technological systems that are used to satisfy human needs and wants, and select them on the basis of safety, cost, and function.**
- **assemble and operate simple technological systems, including those with interconnecting mechanisms to achieve different kinds of movement.**
- **understand that larger systems are made up of smaller component subsystems.**

This is evident, for example, when students:

▲ assemble and operate a system made up from a battery, switch, and doorbell connected in a series circuit.

▲ assemble a system with interconnecting mechanisms, such as a jack-in-the-box that pops up from a box with a hinged lid.

▲ model a community-based transportation system which includes subsystems such as roadways, rails, vehicles, and traffic controls.

Standard 5—Technology

Elementary

History and Evolution of Technology

5. Technology has been the driving force in the evolution of society from an agricultural to an industrial to an information base.

Students:

- **identify technological developments that have significantly accelerated human progress.**

This is evident, for example, when students:

▲ construct a model of an historical or future-oriented technological device or system and describe how it has contributed or might contribute to human progress.
▲ make a technological timeline in the form of a hanging mobile of technological devices.
▲ model a variety of timekeeping devices that reflect historical and modern methods of keeping time.
▲ make a display contrasting early devices or tools with their modern counterparts.

Key ideas are identified by numbers (1).
Performance indicators are identified by bullets (•).
Sample tasks are identified by triangles (▲).

Impacts of Technology

6. Technology can have positive and negative impacts on individuals, society, and the environment and humans have the capability and responsibility to constrain or promote technological development.

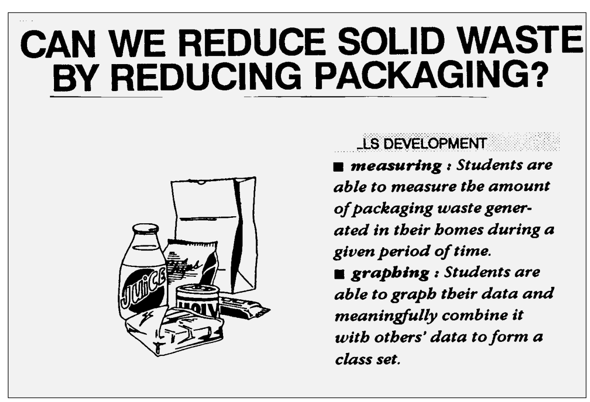
Students:

- **describe how technology can have positive and negative effects on the environment and on the way people live and work.**

This is evident, for example, when students:

▲ handmake an item and then participate in a line production experience where a quantity of the item is mass produced; compare the benefits and disadvantages of mass production and craft production.
▲ describe through example, how familiar technologies (including computers) can have positive and negative impacts on the environment and on the way people live and work.
▲ identify the pros and cons of several possible packaging materials for a student-made product.

Sample Problem/Activity



Students will apply technological knowledge and skills to design, construct, use, and evaluate products and systems to satisfy human and environmental needs.

Management of Technology

7. Project management is essential to ensuring that technological endeavors are profitable and that products and systems are of high quality and built safely, on schedule, and within budget.

Students:

- **participate in small group projects and in structured group tasks requiring planning, financing, production, quality control, and follow-up.**
- **speculate on and model possible technological solutions that can improve the safety and quality of the school or community environment.**

This is evident, for example, when students:

▲ help a group to plan and implement a school project or activity, such as a school picnic or a fund-raising event.

▲ plan as a group, division of tasks and construction steps needed to build a simple model of a structure or vehicle.

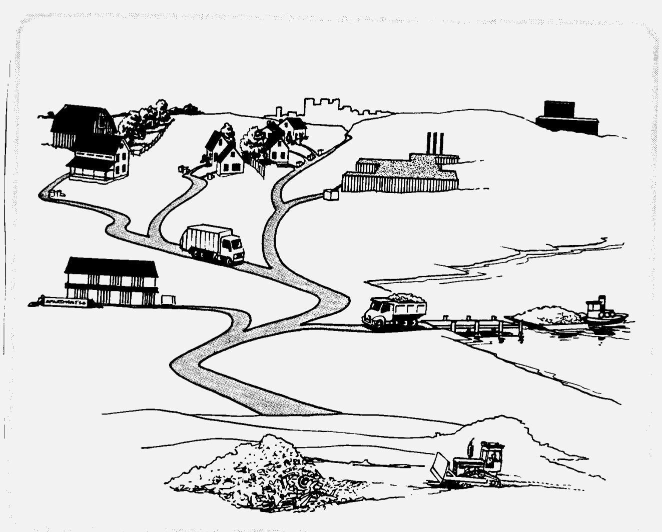
▲ redesign the work area in their classroom with an eye toward improving safety.

Sample Problem/Activity

HOW CAN WE REDUCE SOLID WASTE IN OUR SCHOOL?

Evaluation

Students will be able to develop and implement useful solid waste reduction strategies within their school based upon their investigations of the current solid waste stream.



Standard 5—Technology

Intermediate

Engineering Design

1. Engineering design is an iterative process involving *modeling* and *optimization* used to develop technological solutions to problems within given constraints.

Students engage in the following steps in a design process:

- **identify needs and opportunities for technical solutions from an investigation of situations of general or social interest.**
- **locate and utilize a range of printed, electronic, and human information resources to obtain ideas.**
- **consider constraints and generate several ideas for alternative solutions, using group and individual ideation techniques (group discussion, brainstorming, forced connections, role play); defer judgment until a number of ideas have been generated; evaluate (critique) ideas; and explain why the chosen solution is optimal.**
- **develop plans, including drawings with measurements and details of construction, and construct a model of the solution, exhibiting a degree of craftsmanship.**
- **in a group setting, test their solution against design specifications, present and evaluate results, describe how the solution might have been modified for different or better results, and discuss tradeoffs that might have to be made.**

This is evident, for example, when students:

▲ reflect on the need for alternative growing systems in desert environments and design and model a hydroponic greenhouse for growing vegetables without soil.

▲ brainstorm and evaluate alternative ideas for an adaptive device that will make life easier for a person with a disability, such as a device to pick up objects from the floor.

▲ design a model vehicle (with a safety belt restraint system and crush zones to absorb impact) to carry a raw egg as a passenger down a ramp and into a barrier without damage to the egg.

▲ assess the performance of a solution against various design criteria, enter the scores on a spreadsheet, and see how varying the solution might have affected total score.

Tools, Resources, and Technological Processes

2. Technological tools, materials, and other resources should be selected on the basis of safety, cost, availability, appropriateness, and environmental impact; technological processes change energy, information, and material resources into more useful forms.

Students:

- **choose and use resources for a particular purpose based upon an analysis and understanding of their properties, costs, availability, and environmental impact.**
- **use a variety of hand tools and machines to change materials into new forms through forming, separating, and combining processes, and processes which cause internal change to occur.**
- **combine manufacturing processes with other technological processes to produce, market, and distribute a product.**
- **process energy into other forms and information into more meaningful information.**

This is evident, for example, when students:

▲ choose and use resources to make a model of a building and explain their choice of materials based upon physical properties such as tensile and compressive strength, hardness, and brittleness.

▲ choose materials based upon their acoustic properties to make a set of wind chimes.

▲ use a torch to heat a steel rod to a cherry red color and cool it slowly to demonstrate how the process of annealing changes the internal structure of the steel and removes its brittleness.

▲ change materials into new forms using separate processes such as drilling and sawing.

▲ process energy into other forms such as assembling a solar cooker using a parabolic reflector to convert light energy to heat energy.

▲ process information into more meaningful information such as adding a music track or sound effects to an audio tape.

Key ideas are identified by numbers (1).
Performance indicators are identified by bullets (•).
Sample tasks are identified by triangles (▲).

Students will apply technological knowledge and skills to design, construct, use, and evaluate products and systems to satisfy human and environmental needs.

Computer Technology

3. Computers, as tools for design, modeling, information processing, communication, and system control, have greatly increased human productivity and knowledge.

Students:

- **assemble a computer system including keyboard, central processing unit and disc drives, mouse, modem, printer, and monitor.**
- **use a computer system to connect to and access needed information from various Internet sites.**
- **use computer hardware and software to draw and dimension prototypical designs.**
- **use a computer as a modeling tool.**
- **use a computer system to monitor and control external events and/or systems.**

This is evident, for example, when students:

▲ use computer hardware and a basic computer-aided design package to draw and dimension plans for a simple project.

▲ use a computer program, such as Car Builder, to model a vehicle to desired specifications.

▲ use temperature sensors to monitor and control the temperature of a model greenhouse.

▲ model a computer-controlled system, such as traffic lights, a merry-go-round, or a vehicle using Lego or other modeling hardware interfaced to a computer.

Technological Systems

4. Technological systems are designed to achieve specific results and produce outputs, such as products, structures, services, energy, or other systems.

Students:

- **select appropriate technological systems on the basis of safety, function, cost, ease of operation, and quality of post-purchase support.**
- **assemble, operate, and explain the operation of simple open- and closed-loop electrical, electronic, mechanical, and pneumatic systems.**
- **describe how subsystems and system elements (inputs, processes, outputs) interact within systems.**
- **describe how system control requires sensing information, processing it, and making changes.**

This is evident, for example, when students:

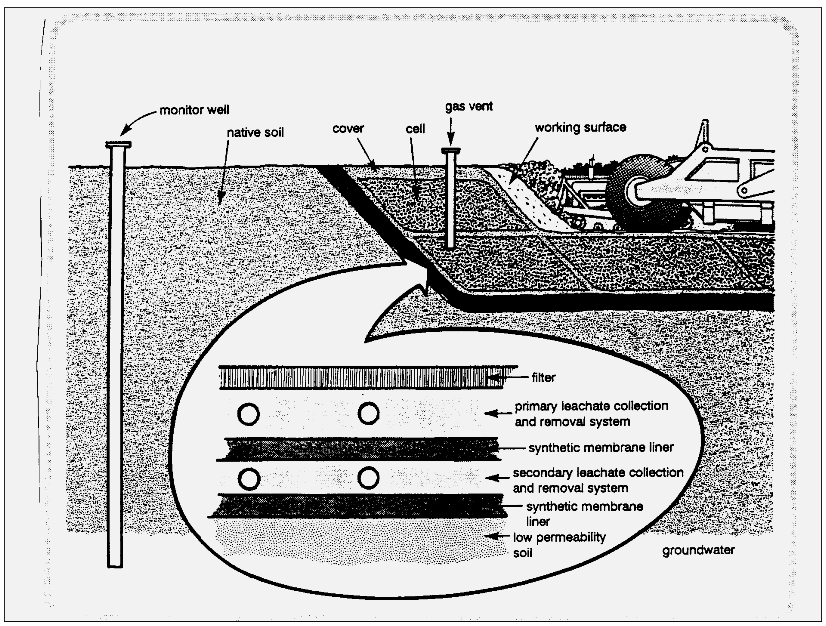
▲ assemble an electronic kit that includes sensors and signaling devices and functions as an alarm system.

▲ use several open loop systems (without feedback control) such as a spray can, bubble gum machine, or wind-up toys, and compare them to closed-loop systems (with feedback control) such as an electric oven with a thermostat, or a line tracker robot.

▲ use a systems diagram to model a technological system, such as a model rocket, with the command inputs, resource inputs, processes, monitoring and control mechanisms, and system outputs labeled.

▲ provide examples of modern machines where microprocessors receive information from sensors and serve as controllers.

Sample Problem/Activity



Systems diagram for a filter system

Standard 5—Technology

Intermediate

History and Evolution of Technology

5. Technology has been the driving force in the evolution of society from an agricultural to an industrial to an information base.

Students:

- **describe how the evolution of technology led to the shift in society from an agricultural base to an industrial base to an information base.**
- **understand the contributions of people of different genders, races, and ethnic groups to technological development.**
- **describe how new technologies have evolved as a result of combining existing technologies (e.g., photography combined optics and chemistry; the airplane combined kite and glider technology with a lightweight gasoline engine).**

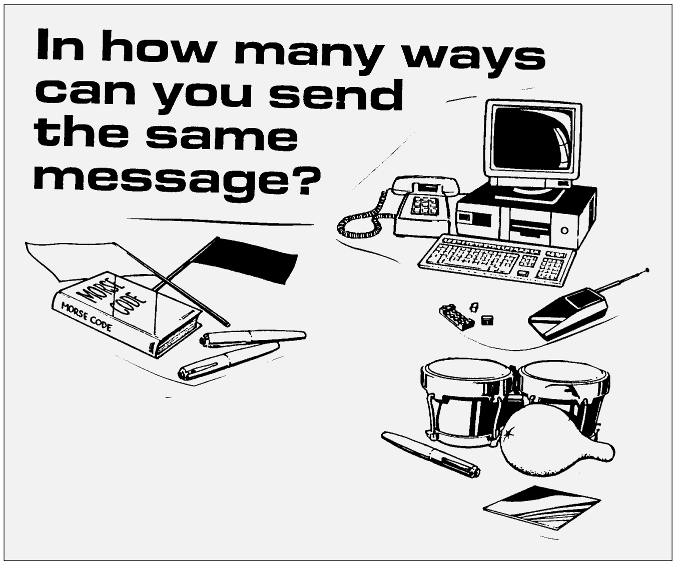
This is evident, for example, when students:

▲ construct models of technological devices (e.g., the plow, the printing press, the digital computer) that have significantly affected human progress and that illustrate how the evolution of technology has shifted the economic base of the country.

▲ develop a display of pictures or models of technological devices invented by people from various cultural backgrounds, along with photographs and short biographies of the inventors.

▲ make a poster with drawings and photographs showing how an existing technology is the result of combining various technologies.

Sample Problem/Activity



Impacts of Technology

6. Technology can have positive and negative impacts on individuals, society, and the environment and humans have the capability and responsibility to constrain or promote technological development.

Students:

- **describe how outputs of a technological system can be desired, undesired, expected, or unexpected.**
- **describe through examples how modern technology reduces manufacturing and construction costs and produces more uniform products.**

This is evident, for example, when students:

▲ use the automobile, for example, to explain desired (easier travel), undesired (pollution), expected (new jobs created), unexpected (crowded highways and the growth of suburbs) impacts.

▲ provide an example of an assembly line that produces products with interchangeable parts.

▲ compare the costs involved in producing a prototype of a product to the per product cost of a batch of 100.

Key ideas are identified by numbers (1).
Performance indicators are identified by bullets (•).
Sample tasks are identified by triangles (▲).

Students will apply technological knowledge and skills to design, construct, use, and evaluate products and systems to satisfy human and environmental needs.

Management of Technology

7. Project management is essential to ensuring that technological endeavors are profitable and that products and systems are of high quality and built safely, on schedule, and within budget.

Students:

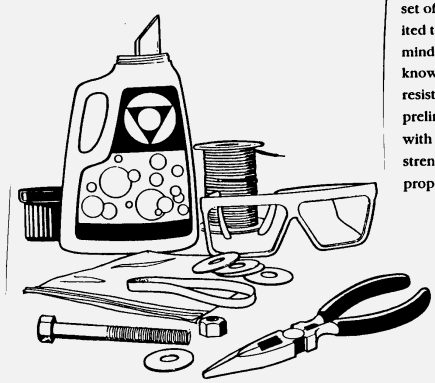
- **manage time and financial resources in a technological project.**
- **provide examples of products that are well (and poorly) designed and made, describe their positive and negative attributes, and suggest measures that can be implemented to monitor quality during production.**
- **assume leadership responsibilities within a structured group activity.**

This is evident, for example, when students:

▲ make up and follow a project work plan, time schedule, budget, and a bill of materials.
▲ analyze a child's toy and describe how it might have been better made at a lower cost.
▲ assume leadership on a team to play an audio or video communication system, and use it for an intended purpose (e.g., to inform, educate, persuade, entertain).

Sample Problem/Activity

Can we build a working speaker?



Classroom Activity

1. Divide the class into groups consisting of four students each. Challenge each group to design a plan for the construction of a homemade radio speaker for the eight-ohm speaker jack on an inexpensive transistor radio or cassette recorder. Provide each group with a set of materials, and inform students that they are limited to the use of these materials in their designs. Remind students to draw upon the information and knowledge they possess about electromagnets, current, resistors, and circuits. After each group has generated a preliminary plan, hold a class discussion. Work out with students a class consensus plan that combines the strengths and minimizes the weaknesses of their group-proposed plans (see Procedural Notes section).

Standard 5—Technology

Commencement

Engineering Design

1. Engineering design is an iterative process involving *modeling* and *optimization* used to develop technological solutions to problems within given constraints.

Students engage in the following steps in a design process:

- **initiate and carry out a thorough investigation of an unfamiliar situation and identify needs and opportunities for technological invention or innovation.**
- **identify, locate, and use a wide range of information resources including subject experts, library references, magazines, videotapes, films, electronic data bases and on-line services, and discuss and document through notes and sketches how findings relate to the problem.**
- **generate creative solution ideas, break ideas into the significant functional elements, and explore possible refinements; predict possible outcomes using mathematical and functional modeling techniques; choose the optimal solution to the problem, clearly documenting ideas against design criteria and constraints; and explain how human values, economics, ergonomics, and environmental considerations have influenced the solution.**
- **develop work schedules and plans which include optimal use and cost of materials, processes, time, and expertise; construct a model of the solution, incorporating developmental modifications while working to a high degree of quality (craftsmanship).**
- **in a group setting, devise a test of the solution relative to the design criteria and perform the test; record, portray, and logically evaluate performance test results through quantitative, graphic, and verbal means; and use a variety of creative verbal and graphic techniques effectively and persuasively to present conclusions, predict impacts and new problems, and suggest and pursue modifications.**

This is evident, for example, when students:

▲ search the Internet for world wide web sites dealing with renewable energy and sustainable living and research the development and design of an energy efficient home.

▲ develop plans, diagrams, and working drawings for the construction of a computer-controlled marble sorting system that simulates how parts on an assembly line are sorted by color.

▲ design and model a portable emergency shelter for a homeless person that could be carried by one person and be heated by the body heat of that person to a life-sustaining temperature when the outside temperature is 20^{o} F.

Tools, Resources, and Technological Processes

2. Technological tools, materials, and other resources should be selected on the basis of safety, cost, availability, appropriateness, and environmental impact; technological processes change energy, information, and material resources into more useful forms.

Students:

- **test, use, and describe the attributes of a range of material (including synthetic and composite materials), information, and energy resources.**
- **select appropriate tools, instruments, and equipment and use them correctly to process materials, energy, and information.**
- **explain tradeoffs made in selecting alternative resources in terms of safety, cost, properties, availability, ease of processing, and disposability.**
- **describe and model methods (including computer-based methods) to control system processes and monitor system outputs.**

This is evident, for example, when students:

▲ use a range of high- tech composite or synthetic materials to make a model of a product, (e.g., ski, an airplane, earthquake-resistant building) and explain their choice of material.

▲ design a procedure to test the properties of synthetic and composite materials.

▲ select appropriate tools, materials, and processes to manufacture a product (chosen on the basis of market research) that appeals to high school students.

▲ select the appropriate instrument and use it to test voltage and continuity when repairing a household appliance.

▲ construct two forms of packaging (one from biodegradable materials, the other from any other materials), for a children's toy and explain the tradeoffs made when choosing one or the other.

▲ describe and model a method to design and evaluate a system that dispenses candy and counts the number dispensed using, for example, Fischertecnik, Capsela, or Lego.

▲ describe how the flow, processing, and monitoring of materials is controlled in a manufacturing plant and how information processing systems provide inventory, tracking, and quality control data.

Key ideas are identified by numbers (1).
Performance indicators are identified by bullets (•).
Sample tasks are identified by triangles (▲).

Students will apply technological knowledge and skills to design, construct, use, and evaluate products and systems to satisfy human and environmental needs.

Computer Technology

3. Computers, as tools for design, modeling, information processing, communication, and system control, have greatly increased human productivity and knowledge.

Students:

- **understand basic computer architecture and describe the function of computer subsystems and peripheral devices.**
- **select a computer system that meets personal needs.**
- **attach a modem to a computer system and telephone line, set up and use communications software, connect to various on-line networks, including the Internet, and access needed information using e-mail, telnet, gopher, ftp, and web searches.**
- **use computer-aided drawing and design (CADD) software to model realistic solutions to design problems.**
- **develop an understanding of computer programming and attain some facility in writing computer programs.**

This is evident, for example, when students:

▲ choose a state-of-the art computer system from computer magazines, price the system, and justify the choice of CPU, CD-ROM and floppy drives, amount of RAM, video and sound cards, modem, printer, and monitor; explain the cost-benefit tradeoffs they have made.

▲ use a computer-aided drawing and design package to design and draw a model of their own room.

▲ write a computer program that works in conjunction with a bar code reader and an optical sensor to distinguish between light and dark areas of the bar code.

Technological Systems

4. Technological systems are designed to achieve specific results and produce outputs, such as products, structures, services, energy, or other systems.

Students:

- **explain why making tradeoffs among characteristics, such as safety, function, cost, ease of operation, quality of post-purchase support, and environmental impact, is necessary when selecting systems for specific purposes.**
- **model, explain, and analyze the performance of a feedback control system.**
- **explain how complex technological systems involve the confluence of numerous other systems.**

This is evident, for example, when students:

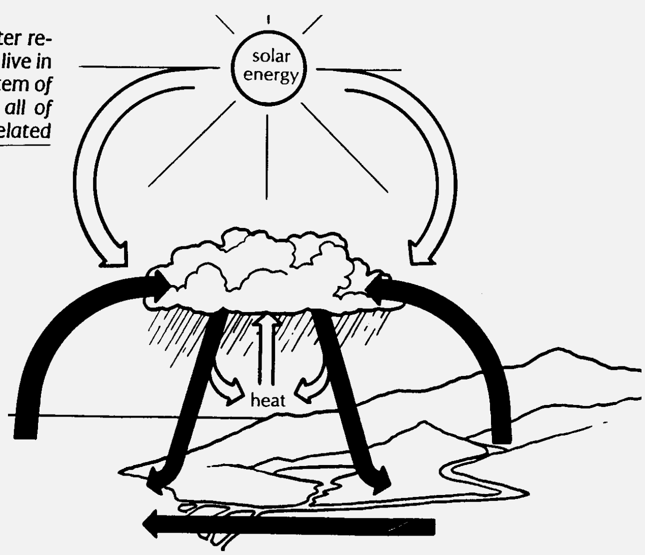
▲ model, explain, and analyze how the float mechanism of a toilet tank senses water level, compares the actual level to the desired level, and controls the flow of water into the tank.

▲ draw a labeled system diagram which explains the performance of a system, and include several subsystems and multiple feedback loops.

▲ explain how the space shuttle involves communication, transportation, biotechnical, and manufacturing systems.

Sample Problem/Activity

Students map their local water resources and realize that they live in a watershed that is a subsystem of increasingly larger systems, all of which constitute an interrelated water cycle.



Standard 5—Technology

Commencement

History and Evolution of Technology

5. Technology has been the driving force in the evolution of society from an agricultural to an industrial to an information base.

Students:

- **explain how technological inventions and innovations have caused global growth and interdependence, stimulated economic competitiveness, created new jobs, and made other jobs obsolete.**

This is evident, for example, when students:

▲ compare qualitatively and quantitatively the performance of a contemporary manufactured product, such as a household appliance, to the comparable device or system 50-100 years ago, and present results graphically, orally, and in writing.

▲ describe the process that an inventor must follow to obtain a patent for an invention.

▲ explain through examples how some inventions are not translated into products and services with market place demand, and therefore do not become commercial successes.

Impacts of Technology

6. Technology can have positive and negative impacts on individuals, society, and the environment and humans have the capability and responsibility to constrain or promote technological development.

Students:

- **explain that although technological effects are complex and difficult to predict accurately, humans can control the development and implementation of technology.**
- **explain how computers and automation have changed the nature of work.**
- **explain how national security is dependent upon both military and nonmilitary applications of technology.**

This is evident, for example, when students:

▲ develop and implement a technological device that might be used to assist a disabled person perform a task.

▲ identify a technology which impacts negatively on the environment and design and model a technological fix.

▲ identify new or emerging technologies and use a futuring technique (e.g., futures wheel, cross impact matrix, Delphi survey) to predict what might be the second and third order impacts.

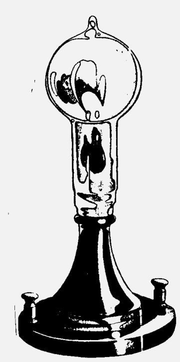
Sample Problem/Activity

How Has The Use Of Electric Appliances Changed Over Time?

Have each student make a list of the electric appliances in her/his household, including everything from light bulbs to refrigerators. Instruct students to ask a parent (or other adult of approximately the same age) to record how many of each kind of appliance was in her/his household when (s)he was a child. Develop with the class a set of common procedures that can be used to collect the information.

➢ What specific procedures should we follow to ensure that everyone's data is comparable?

➢ How will we account for missing data in our survey, due to forgetfulness of some participants or other factors?



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Management of Technology

7. Project management is essential to ensuring that technological endeavors are profitable and that products and systems are of high quality and built safely, on schedule, and within budget.

Students:

- **develop and use computer-based scheduling and project tracking tools, such as flow charts and graphs.**
- **explain how statistical process control helps to assure high quality output.**
- **discuss the role technology has played in the operation of successful U.S. businesses and under what circumstances they are competitive with other countries.**
- **explain how technological inventions and innovations stimulate economic competitiveness and how, in order for an innovation to lead to commercial success, it must be translated into products and services with marketplace demand.**
- **describe new management techniques (e.g., computer-aided engineering, computer-integrated manufacturing, total quality management, just-in-time manufacturing), incorporate some of these in a technological endeavor, and explain how they have reduced the length of design-to-manufacture cycles, resulted in more flexible factories, and improved quality and customer satisfaction.**
- **help to manage a group engaged in planning, designing, implementation, and evaluation of a project to gain understanding of the management dynamics.**

This is evident, for example, when students:

▲ design and carry out a plan to create a computer-based information system that could be used to help manage a manufacturing system (e.g., monitoring inventory, measurement of production rate, development of a safety signal).

▲ identify several successful companies and explain the reasons for their commercial success.

▲ organize and implement an innovative project, based on market research, that involves design, production, testing, marketing, and sales of a product or a service.