Appendix 4 Schoolyard Ecology Leaders' Handbook

Ecology & inquiry frameworks

Frameworks for Schoolyard Ecology

Curriculum Frameworks

- National Science Standards
  - Life Science K-4, 5-8
  - Earth and Space Science K-4, 5-8
  - Science and Technology K-4, 5-8
  - Science in Personal and Social Perspectives K-4, 5-8
  - History and Nature of Science K-4, 5-8
- Michigan Curriculum Framework

Ecology Content & Inquiry Frameworks

- Feinsinger's Framework of Ecology Themes for Schoolyard Ecology
- Ecological Literacy Framework by Paul Risser
- Ecological Literacy Framework by David Orr
- Framework of Understandings for Ecological Literacy by Alan Berkowitz
- NAAEE Framework for Environmental Literacy
- Inquiries and Metaphors for Ecological Principles by Chris Myers
- Ecology Content Frameworks - Logan, Utah
- AAAS Project 2061 Benchmarks
- National Science Education Standards for Inquiry
  - What Should Students Understand About Scientific Inquiry?
  - What Abilities are Necessary to do Scientific Inquiry?

Teaching

- Checklist of Constructivist Teaching
- NSES Teaching Standards

Professional Development

- NSES Professional Development Standards

National Science Standards, Life Science

CONTENT STANDARDS: K-4

Content Standard C:
As a result of activities in grades K-4, all students should develop understanding of:

THE CHARACTERISTICS OF ORGANISMS

- Organisms have basic needs. For example, animals need air, water, and food; plants require air, water, nutrients, and light. Organisms can survive only in environments in which their needs can be met. The world has many different environments, and distinct environments support the life of different types of organisms.
- Each plant or animal has different structures that serve different functions in growth, survival, and reproduction. For example, humans have distinct body structures for walking, holding, seeing, and talking.
- The behavior of individual organisms is influenced by internal cues (such as hunger) and by external cues (such as a change in the environment). Humans and other organisms have senses that help them detect internal and external cues.

LIFE CYCLES OF ORGANISMS

- Plants and animals have life cycles that include being born, developing into adults, reproducing, and eventually dying. The details of this life cycle are different for different organisms.
- Plants and animals closely resemble their parents.
- Many characteristics of an organism are inherited from the parents of the organism, but other characteristics result from an individual's interactions with the environment. Inherited characteristics include the color of flowers and the number of limbs of an animal. Other features, such as the ability to ride a bicycle, are learned through interactions with the environment and cannot be passed on to the next generation.

ORGANISMS AND THEIR ENVIRONMENTS

- All animals depend on plants. Some animals eat plants for food. Other animals eat animals that eat the plants.
- An organism's patterns of behavior are related to the nature of that organism's environment, including the kinds and numbers of other organisms present, the availability of food and resources, and the physical characteristics of the environment. When the environment changes, some plants and animals survive and reproduce, and others die or move to new locations. [See Content Standard F (grades K-4)]
- All organisms cause changes in the environment where they live. Some of these changes are detrimental to the organism or other organisms, whereas others are beneficial.
- Humans depend on their natural and constructed environments. Humans change environments in ways that can be either beneficial or detrimental for themselves and other organisms.

CONTENT STANDARDS: 5-8

Content Standard C:
As a result of their activities in grades 5-8, all students should develop understanding of:

STRUCTURE AND FUNCTION IN LIVING SYSTEMS

- Living systems at all levels of organization demonstrate the complementary nature of structure and function. Important levels of organization for structure and function include cells, organs, tissues, organ systems, whole organisms, and ecosystems. **[See Unifying Concepts and Processes]**
- All organisms are composed of cells--the fundamental unit of life. Most organisms are single cells; other organisms, including humans, are multicellular.
- Cells carry on the many functions needed to sustain life. They grow and divide, thereby producing more cells. This requires that they take in nutrients, which they use to provide energy for the work that cells do and to make the materials that a cell or an organism needs.
- Specialized cells perform specialized functions in multicellular organisms. Groups of specialized cells cooperate to form a tissue, such as a muscle. Different tissues are in turn grouped together to form larger functional units, called organs. Each type of cell, tissue, and organ has a distinct structure and set of functions that serve the organism as a whole.
- The human organism has systems for digestion, respiration, reproduction, circulation, excretion, movement, control, and coordination, and for protection from disease. These systems interact with one another.
- Disease is a breakdown in structures or functions of an organism. Some diseases are the result of intrinsic failures of the system. Others are the result of damage by infection by other organisms.

REPRODUCTION AND HEREDITY

- Reproduction is a characteristic of all living systems; because no individual organism lives forever, reproduction is essential to the continuation of every species. Some organisms reproduce asexually. Other organisms reproduce sexually.
- In many species, including humans, females produce eggs and males produce sperm. Plants also reproduce sexually--the egg and sperm are produced in the flowers of flowering plants. An egg and sperm unite to begin development of a new individual. That new individual receives genetic information from its mother (via the egg) and its father (via the sperm). Sexually produced offspring never are identical to either of their parents.
- Every organism requires a set of instructions for specifying its traits. Heredity is the passage of these instructions from one generation to another.
- Hereditary information is contained in genes, located in the chromosomes of each cell. Each gene carries a single unit of information. An inherited trait of an individual can be determined by one or by many genes, and a single gene can influence more than one trait. A human cell contains many thousands of different genes.
- The characteristics of an organism can be described in terms of a combination of traits. Some traits are inherited and others result from interactions with the environment.

REGULATION AND BEHAVIOR

- All organisms must be able to obtain and use resources, grow, reproduce, and maintain stable internal conditions while living in a constantly changing external environment.
- Regulation of an organism's internal environment involves sensing the internal environment and changing physiological activities to keep conditions within the range required to survive.
- Behavior is one kind of response an organism can make to an internal or environmental stimulus. A behavioral response requires coordination and communication at many levels, including cells, organ systems, and whole organisms. Behavioral response is a set of actions determined in part by heredity and in part from experience.
- An organism's behavior evolves through adaptation to its environment. How a species moves, obtains food, reproduces, and responds to danger are based in the species' evolutionary history.

POPULATIONS AND ECOSYSTEMS

- A population consists of all individuals of a species that occur together at a given place and time. All populations living together and the physical factors with which they interact compose an ecosystem.
- Populations of organisms can be categorized by the function they serve in an ecosystem. Plants and some micro-organisms are producers--they make their own food. All animals, including humans, are consumers, which obtain food by eating other organisms. Decomposers, primarily bacteria and fungi, are consumers that use waste materials and dead organisms for food. Food webs identify the relationships among producers, consumers, and decomposers in an ecosystem.
- For ecosystems, the major source of energy is sunlight. Energy entering ecosystems as sunlight is transferred by producers into chemical energy through photosynthesis. That energy then passes from organism to organism in food webs.
- The number of organisms an ecosystem can support depends on the resources available and abiotic factors, such as quantity of light and water, range of temperatures, and soil composition. Given adequate biotic and abiotic resources and no disease or predators, populations (including humans) increase at rapid rates. Lack of resources and other factors, such as predation and climate, limit the growth of populations in specific niches in the ecosystem.

DIVERSITY AND ADAPTATIONS OF ORGANISMS

- Millions of species of animals, plants, and microorganisms are alive today. Although different species might look dissimilar, the unity among organisms becomes apparent from an analysis of internal structures, the similarity of their chemical processes, and the evidence of common ancestry.
- Biological evolution accounts for the diversity of species developed through gradual processes over many generations. Species acquire many of their unique characteristics through biological adaptation, which involves the selection of naturally occurring variations in populations. Biological adaptations include changes in structures, behaviors, or physiology that enhance survival and reproductive success in a particular environment.
- Extinction of a species occurs when the environment changes and the adaptive characteristics of a species are insufficient to allow its survival. Fossils indicate that many organisms that lived long ago are extinct. Extinction of species is common; most of the species that have lived on the earth no longer exist.

Top of page | Main appendix List | Back to Appendix 4 | Table of Contents
Help | About IES | Search | Print | Forums | Contact us | Home

Appendix 4 Schoolyard Ecology Leaders' Handbook

Ecology & inquiry frameworks

National Science Standards, Earth and Space Science

CONTENT STANDARDS: K-4

Content Standard D:
As a result of their activities in grades K-4, all students should develop an understanding of:

PROPERTIES OF EARTH MATERIALS

- Earth materials are solid rocks and soils, water, and the gases of the atmosphere. The varied materials have different physical and chemical properties, which make them useful in different ways, for example, as building materials, as sources of fuel, or for growing the plants we use as food. Earth materials provide many of the resources that humans use.
- Soils have properties of color and texture, capacity to retain water, and ability to support the growth of many kinds of plants, including those in our food supply.
- Fossils provide evidence about the plants and animals that lived long ago and the nature of the environment at that time.

OBJECTS IN THE SKY

- The sun, moon, stars, clouds, birds, and airplanes all have properties, locations, and movements that can be observed and described.
- The sun provides the light and heat necessary to maintain the temperature of the earth.

CHANGES IN THE EARTH AND SKY

- The surface of the earth changes. Some changes are due to slow processes, such as erosion and weathering, and some changes are due to rapid processes, such as landslides, volcanic eruptions, and earthquakes.
- Weather changes from day to day and over the seasons. Weather can be described by measurable quantities, such as temperature, wind direction and speed, and precipitation.
- Objects in the sky have patterns of movement. The sun, for example, appears to move across the sky in the same way every day, but its path changes slowly over the seasons. The moon moves across the sky on a daily basis much like the sun. The observable shape of the moon changes from day to day in a cycle that lasts about a month.

CONTENT STANDARDS: 5-8

Content Standard D:
As a result of their activities in grades 5-8, all students should develop an understanding of:

STRUCTURE OF THE EARTH SYSTEM

- The solid earth is layered with a lithosphere; hot, convecting mantle; and dense, metallic core.
- Lithospheric plates on the scales of continents and oceans constantly move at rates of centimeters per year in response to movements in the mantle. Major geological events, such as earthquakes, volcanic eruptions, and mountain building, result from these plate motions. [See Content Standard F (grades 5-8)]

- Land forms are the result of a combination of constructive and destructive forces. Constructive forces include crustal deformation, volcanic eruption, and deposition of sediment, while destructive forces include weathering and erosion.
- Some changes in the solid earth can be described as the "rock cycle." Old rocks at the earth's surface weather, forming sediments that are buried, then compacted, heated, and often recrystallized into new rock. Eventually, those new rocks may be brought to the surface by the forces that drive plate motions, and the rock cycle continues.
- Soil consists of weathered rocks and decomposed organic material from dead plants, animals, and bacteria. Soils are often found in layers, with each having a different chemical composition and texture.
- Water, which covers the majority of the earth's surface, circulates through the crust, oceans, and atmosphere in what is known as the "water cycle." Water evaporates from the earth's surface, rises and cools as it moves to higher elevations, condenses as rain or snow, and falls to the surface where it collects in lakes, oceans, soil, and in rocks underground.
- Water is a solvent. As it passes through the water cycle it dissolves minerals and gases and carries them to the oceans.
- The atmosphere is a mixture of nitrogen, oxygen, and trace gases that include water vapor. The atmosphere has different properties at different elevations.
- Clouds, formed by the condensation of water vapor, affect weather and climate.
- Global patterns of atmospheric movement influence local weather. Oceans have a major effect on climate, because water in the oceans holds a large amount of heat.
- Living organisms have played many roles in the earth system, including affecting the composition of the atmosphere, producing some types of rocks, and contributing to the weathering of rocks.

EARTH'S HISTORY

- The earth processes we see today, including erosion, movement of lithospheric plates, and changes in atmospheric composition, are similar to those that occurred in the past. earth history is also influenced by occasional catastrophes, such as the impact of an asteroid or comet.
- Fossils provide important evidence of how life and environmental conditions have changed. [See Content Standard C (grades 5-8)]

EARTH IN THE SOLAR SYSTEM

- The earth is the third planet from the sun in a system that includes the moon, the sun, eight other planets and their moons, and smaller objects, such as asteroids and comets. The sun, an average star, is the central and largest body in the solar system. **[See Unifying Concepts and Processes]**
- Most objects in the solar system are in regular and predictable motion. Those motions explain such phenomena as the day, the year, phases of the moon, and eclipses.
- Gravity is the force that keeps planets in orbit around the sun and governs the rest of the motion in the solar system. Gravity alone holds us to the earth's surface and explains the phenomena of the tides.
- The sun is the major source of energy for phenomena on the earth's surface, such as growth of plants, winds, ocean currents, and the water cycle. Seasons result from variations in the amount of the sun's energy hitting the surface, due to the tilt of the earth's rotation on its axis and the length of the day.

Top of page | Main appendix List | Back to Appendix 4 | Table of Contents
Help | About IES | Search | Print | Forums | Contact us | Home

National Science Standards, Science and Technology

CONTENT STANDARDS: K-4

Content Standard E:
As a result of activities in grades K-4, all students should develop:

ABILITIES OF TECHNOLOGICAL DESIGN

IDENTIFY A SIMPLE PROBLEM. In problem identification, children should develop the ability to explain a problem in their own words and identify a specific task and solution related to the problem. **[See Content Standard A (grades K-4)]**
PROPOSE A SOLUTION. Students should make proposals to build something or get something to work better; they should be able to describe and communicate their ideas. Students should recognize that designing a solution might have constraints, such as cost, materials, time, space, or safety.
IMPLEMENTING PROPOSED SOLUTIONS. Children should develop abilities to work individually and collaboratively and to use suitable tools, techniques, and quantitative measurements when appropriate. Students should demonstrate the ability to balance simple constraints in problem solving.
EVALUATE A PRODUCT OR DESIGN. Students should evaluate their own results or solutions to problems, as well as those of other children, by considering how well a product or design met the challenge to solve a problem. When possible, students should use measurements and include constraints and other criteria in their evaluations. They should modify designs based on the results of evaluations.
COMMUNICATE A PROBLEM, DESIGN, AND SOLUTION. Student abilities should include oral, written, and pictorial communication of the design process and product. The communication might be show and tell, group discussions, short written reports, or pictures, depending on the students' abilities and the design project.

UNDERSTANDING ABOUT SCIENCE AND TECHNOLOGY

- People have always had questions about their world. Science is one way of answering questions and explaining the natural world.
- People have always had problems and invented tools and techniques (ways of doing something) to solve problems. Trying to determine the effects of solutions helps people avoid some new problems.
- Scientists and engineers often work in teams with different individuals doing different things that contribute to the results. This understanding focuses primarily on teams working together and secondarily, on the combination of scientist and engineer teams.
- Women and men of all ages, backgrounds, and groups engage in a variety of scientific and technological work.
- Tools help scientists make better observations, measurements, and equipment for investigations. They help scientists see, measure, and do things that they could not otherwise see, measure, and do.

ABILITIES TO DISTINGUISH BETWEEN NATURAL OBJECTS AND OBJECTS MADE BY HUMANS

- Some objects occur in nature; others have been designed and made by people to solve human problems and enhance the quality of life.
- Objects can be categorized into two groups, natural and designed.

CONTENT STANDARDS: 5-8

Content Standards E:
As a result of activities in grades 5-8, all students should develop:

ABILITIES OF TECHNOLOGICAL DESIGN

IDENTIFY APPROPRIATE PROBLEMS FOR TECHNOLOGICAL DESIGN. Students should develop their abilities by identifying a specified need, considering its various aspects, and talking to different potential users or beneficiaries. They should appreciate that for some needs, the cultural backgrounds and beliefs of different groups can affect the criteria for a suitable product. **[See Content Standard A (grades 5-8)]**
DESIGN A SOLUTION OR PRODUCT. Students should make and compare different proposals in the light of the criteria they have selected. They must consider constraints--such as cost, time, trade-offs, and materials needed--and communicate ideas with drawings and simple models.
IMPLEMENT A PROPOSED DESIGN. Students should organize materials and other resources, plan their work, make good use of group collaboration where appropriate, choose suitable tools and techniques, and work with appropriate measurement methods to ensure adequate accuracy.
EVALUATE COMPLETED TECHNOLOGICAL DESIGNS OR PRODUCTS. Students should use criteria relevant to the original purpose or need, consider a variety of factors that might affect acceptability and suitability for intended users or beneficiaries, and develop measures of quality with respect to such criteria and factors; they should also suggest improvements and, for their own products, try proposed modifications.
COMMUNICATE THE PROCESS OF TECHNOLOGICAL DESIGN. Students should review and describe any completed piece of work and identify the stages of problem identification, solution design, implementation, and evaluation. **[See Teaching Standard B]**

UNDERSTANDINGS ABOUT SCIENCE AND TECHNOLOGY

- Scientific inquiry and technological design have similarities and differences. Scientists propose explanations for questions about the natural world, and engineers propose solutions relating to human problems, needs, and aspirations. Technological solutions are temporary; technologies exist within nature and so they cannot contravene physical or biological principles; technological solutions have side effects; and technologies cost, carry risks, and provide benefits. **[See Content Standards A, F, & G (grades 5-8)]**
- Many different people in different cultures have made and continue to make contributions to science and technology.
- Science and technology are reciprocal. Science helps drive technology, as it addresses questions that demand more sophisticated instruments and provides principles for better instrumentation and technique. Technology is essential to science, because it provides instruments and techniques that enable observations of objects and phenomena that are otherwise unobservable due to factors such as quantity, distance, location, size, and speed. Technology also provides tools for investigations, inquiry, and analysis.
- Perfectly designed solutions do not exist. All technological solutions have trade-offs, such as safety, cost, efficiency, and appearance. Engineers often build in back-up systems to provide safety. Risk is part of living in a highly technological world. Reducing risk often results in new technology.
- Technological designs have constraints. Some constraints are unavoidable, for example, properties of materials, or effects of weather and friction; other constraints limit choices in the design, for example, environmental protection, human safety, and aesthetics.
- Technological solutions have intended benefits and unintended consequences. Some consequences can be predicted, others cannot.

Appendix 4 Schoolyard Ecology Leaders' Handbook

Ecology & inquiry frameworks

National Science Standards, Science in Personal and Social Perspectives

CONTENT STANDARDS: K-4

Content Standard F:
As a result of activities in grades K-4, all students should develop understanding of:

PERSONAL HEALTH

- Safety and security are basic needs of humans. Safety involves freedom from danger, risk, or injury. Security involves feelings of confidence and lack of anxiety and fear. Student understandings include following safety rules for home and school, preventing abuse and neglect, avoiding injury, knowing whom to ask for help, and when and how to say no.
- Individuals have some responsibility for their own health. Students should engage in personal care--dental hygiene, cleanliness, and exercise--that will maintain and improve health. Understandings include how communicable diseases, such as colds, are transmitted and some of the body's defense mechanisms that prevent or overcome illness.
- Nutrition is essential to health. Students should understand how the body uses food and how various foods contribute to health. Recommendations for good nutrition include eating a variety of foods, eating less sugar, and eating less fat.
- Different substances can damage the body and how it functions. Such substances include tobacco, alcohol, over-the-counter medicines, and illicit drugs. Students should understand that some substances, such as prescription drugs, can be beneficial, but that any substance can be harmful if used inappropriately.

CHARACTERISTICS AND CHANGES IN POPULATIONS

- Human populations include groups of individuals living in a particular location. One important characteristic of a human population is the population density--the number of individuals of a particular population that lives in a given amount of space.
- The size of a human population can increase or decrease. Populations will increase unless other factors such as disease or famine decrease the population.

TYPES OF RESOURCES

- Resources are things that we get from the living and nonliving environment to meet the needs and wants of a population.
- Some resources are basic materials, such as air, water, and soil; some are produced from basic resources, such as food, fuel, and building materials; and some resources are nonmaterial, such as quiet places, beauty, security, and safety. [See Content Standard D (grades K-4)]
- The supply of many resources is limited. If used, resources can be extended through recycling and decreased use.

CHANGES IN ENVIRONMENTS

- Environments are the space, conditions, and factors that affect an individual's and a population's ability to survive and their quality of life. [See Content Standard C (grades K-4)]
- Changes in environments can be natural or influenced by humans. Some changes are good, some are bad, and some are neither good nor bad. Pollution is a change in the environment that can influence the health, survival, or activities of organisms, including humans.
- Some environmental changes occur slowly, and others occur rapidly. Students should understand the different consequences of changing environments in small increments over long periods as compared with changing environments in large increments over short periods.
- Science and technology in local challenges

CONTENT STANDARDS: 5-8

Content Standard F:
As a result of activities in grades 5-8, all students should develop understanding of:

PERSONAL HEALTH

- Regular exercise is important to the maintenance and improvement of health. The benefits of physical fitness include maintaining healthy weight, having energy and strength for routine activities, good muscle tone, bone strength, strong heart/lung systems, and improved mental health. Personal exercise, especially developing cardiovascular endurance, is the foundation of physical fitness.
- The potential for accidents and the existence of hazards imposes the need for injury prevention. Safe living involves the development and use of safety precautions and the recognition of risk in personal decisions. Injury prevention has personal and social dimensions.
- The use of tobacco increases the risk of illness. Students should understand the influence of short-term social and psychological factors that lead to tobacco use, and the possible long-term detrimental effects of smoking and chewing tobacco.
- Alcohol and other drugs are often abused substances. Such drugs change how the body functions and can lead to addiction.
- Food provides energy and nutrients for growth and development. Nutrition requirements vary with body weight, age, sex, activity, and body functioning.
- Sex drive is a natural human function that requires understanding. Sex is also a prominent means of transmitting diseases. The diseases can be prevented through a variety of precautions.
- Natural environments may contain substances (for example, radon and lead) that are harmful to human beings. Maintaining environmental health involves establishing or monitoring quality standards related to use of soil, water, and air.

POPULATIONS, RESOURCES, AND ENVIRONMENTS

- When an area becomes overpopulated, the environment will become degraded due to the increased use of resources.
- Causes of environmental degradation and resource depletion vary from region to region and from country to country.

NATURAL HAZARDS

- Internal and external processes of the earth system cause natural hazards, events that change or destroy human and wildlife habitats, damage property, and harm or kill humans. Natural hazards include earthquakes, landslides, wildfires, volcanic eruptions, floods, storms, and even possible impacts of asteroids. [See Content Standard D (grades 5-8)]
- Human activities also can induce hazards through resource acquisition, urban growth, land-use decisions, and waste disposal. Such activities can accelerate many natural changes.
- Natural hazards can present personal and societal challenges because misidentifying the change or

incorrectly estimating the rate and scale of change may result in either too little attention and significant human costs or too much cost for unneeded preventive measures.

RISKS AND BENEFITS

- Risk analysis considers the type of hazard and estimates the number of people that might be exposed and the number likely to suffer consequences. The results are used to determine the options for reducing or eliminating risks.
- Students should understand the risks associated with natural hazards (fires, floods, tornadoes, hurricanes, earthquakes, and volcanic eruptions), with chemical hazards (pollutants in air, water, soil, and food), with biological hazards (pollen, viruses, bacterial, and parasites), social hazards (occupational safety and transportation), and with personal hazards (smoking, dieting, and drinking).
- Individuals can use a systematic approach to thinking critically about risks and benefits. Examples include applying probability estimates to risks and comparing them to estimated personal and social benefits.
- Important personal and social decisions are made based on perceptions of benefits and risks.

SCIENCE AND TECHNOLOGY IN SOCIETY

- Science influences society through its knowledge and world view. Scientific knowledge and the procedures used by scientists influence the way many individuals in society think about themselves, others, and the environment. The effect of science on society is neither entirely beneficial nor entirely detrimental. [See Content Standard E (grades 5-8)]
- Societal challenges often inspire questions for scientific research, and social priorities often influence research priorities through the availability of funding for research.
- Technology influences society through its products and processes. Technology influences the quality of life and the ways people act and interact. Technological changes are often accompanied by social, political, and economic changes that can be beneficial or detrimental to individuals and to society. Social needs, attitudes, and values influence the direction of technological development.
- Science and technology have advanced through contributions of many different people, in different cultures, at different times in history. Science and technology have contributed enormously to economic growth and productivity among societies and groups within societies.
- Scientists and engineers work in many different settings, including colleges and universities, businesses and industries, specific research institutes, and government agencies.
- Scientists and engineers have ethical codes requiring that human subjects involved with research be fully informed about risks and benefits associated with the research before the individuals choose to participate. This ethic extends to potential risks to communities and property. In short, prior knowledge and consent are required for research involving human subjects or potential damage to property.
- Science cannot answer all questions and technology cannot solve all human problems or meet all human needs. Students should understand the difference between scientific and other questions. They should appreciate what science and technology can reasonably contribute to society and what they cannot do. For example, new technologies often will decrease some risks and increase others.

National Science Standards, History and Nature of Science

CONTENT STANDARDS: K-4

Content Standard G:
As a result of activities in grades K-4, all students should develop understanding of:

SCIENCE AS A HUMAN ENDEAVOR

- Science and technology have been practiced by people for a long time.
- Men and women have made a variety of contributions throughout the history of science and technology.
- Although men and women using scientific inquiry have learned much about the objects, events, and phenomena in nature, much more remains to be understood. Science will never be finished.
- Many people choose science as a career and devote their entire lives to studying it. Many people derive great pleasure from doing science.

> "*Science and technology have advanced through the contributions of many different people in different cultures at different times in history.*

CONTENT STANDARDS: 5-8

Content Standard G:
As a result of activities in grades 5-8, all students should develop understanding of:

SCIENCE AS A HUMAN ENDEAVOR

- Women and men of various social and ethnic backgrounds--and with diverse interests, talents, qualities, and motivations--engage in the activities of science, engineering, and related fields such as the health professions. Some scientists work in teams, and some work alone, but all communicate extensively with others.
- Science requires different abilities, depending on such factors as the field of study and type of inquiry. Science is very much a human endeavor, and the work of science relies on basic human qualities, such as reasoning, insight, energy, skill, and creativity--as well as on scientific habits of mind, such as intellectual honesty, tolerance of ambiguity, skepticism, and openness to new ideas.

NATURE OF SCIENCE

- Scientists formulate and test their explanations of nature using observation, experiments, and theoretical and mathematical models. Although all scientific ideas are tentative and subject to change and improvement in principle, for most major ideas in science, there is much experimental and observational confirmation. Those ideas are not likely to change greatly in the future. Scientists do and have changed their ideas about nature when they encounter new experimental evidence that does not match their existing explanations.

- In areas where active research is being pursued and in which there is not a great deal of experimental or observational evidence and understanding, it is normal for scientists to differ with one another about the interpretation of the evidence or theory being considered. Different scientists might publish conflicting experimental results or might draw different conclusions from the same data. Ideally, scientists acknowledge such conflict and work towards finding evidence that will resolve their disagreement.
- It is part of scientific inquiry to evaluate the results of scientific investigations, experiments, observations, theoretical models, and the explanations proposed by other scientists. Evaluation includes reviewing the experimental procedures, examining the evidence, identifying faulty reasoning, pointing out statements that go beyond the evidence, and suggesting alternative explanations for the same observations. Although scientists may disagree about explanations of phenomena, about interpretations of data, or about the value of rival theories, they do agree that questioning, response to criticism, and open communication are integral to the process of science. As scientific knowledge evolves, major disagreements are eventually resolved through such interactions between scientists.

> *“Students should understand the difference between scientific and other questions and what science and technology can and cannot reasonably contribute to society.*

HISTORY OF SCIENCE

- Many individuals have contributed to the traditions of science. Studying some of these individuals provides further understanding of scientific inquiry, science as a human endeavor, the nature of science, and the relationships between science and society.
- In historical perspective, science has been practiced by different individuals in different cultures. In looking at the history of many peoples, one finds that scientists and engineers of high achievement are considered to be among the most valued contributors to their culture.
- Tracing the history of science can show how difficult it was for scientific innovators to break through the accepted ideas of their time to reach the conclusions that we currently take for granted.

Appendix 4 Schoolyard Ecology Leaders' Handbook

Ecology & inquiry frameworks

Michigan Curriculum Framework

Michigan SYEFEST Inquiries and the Michigan Science Content Standards - Elementary

Inquiry	I.1.,1	I.1.,2	I.1.,3	I.1.,4	I.1.,5	I.1.,6	II.1.,1	II.1.,2	II.1.,3	II.1.,4	II.1.,5
Color Bugs	X	X		X	X	X	X	X		X	
Ant Cafeteria	X	X		X	X	X	X	X		X	
Leaves of Steel(c)	X	X	X	X	X	X	X	X	X	X	
Litter Critters(a)	X	X			X	X	X	X		X	
Mark-Recapture	X	X			X	X	X	X		X	
Mystery Marauders(a)	X	X			X	X	X	X		X	
Chemical Warfare(b)	X	X		X	X	X	X	X		X	
Wings on Seeds(c)	X	X		X	X	X	X	X		X	
Seed Robber Detectives	X	X			X	X	X	X		X	
Impacts of SY Traffic & Decomposers	X	X		X	X	X	X	X		X	
Acorn Weevils	X	X			X	X	X	X		X	
Size of Nature Preserves	X	X		X	X	X	X	X		X	
Pollution in Snow(c,d)	X	X		X	X	X	X	X		X	
Animal Antifreeze(a,c)	X	X		X	X	X	X	X		X	

Inquiry	III.1.,1	III.2.,1	III.2.,2	III.2.,3	III.2.,4	III.2.,5	III.3.,1
Color Bugs		X			X		
Ant Cafeteria		X		X	X		
Leaves of Steel(c)		X			X	X	
Litter Critters(a)		X		X	X		
Mark-Recapture		X			X		
Mystery Marauders(a)		X			X	X	
Chemical Warfare(b)		X		X	X	X	
Wings on Seeds(c)		X		X	X	X	X
Seed Robber Detectives		X	X		X	X	
Impacts of SY Traffic & Decomposers	X	X			X		
Acorn Weevils		X		X	X	X	X
Size of Nature Preserves		X			X		
Pollution in Snow(c,d)					X		

Animal Antifreeze(a,c)			X		X		

Inquiry	III.4.,1	III.4.,2	III.5.,1	III.5.,2	III.5.,3	III.5.,4	III.5.,5
Color Bugs		X	X	X	X		X
Ant Cafeteria		X	X	X	X		X
Leaves of Steel(c)		X		X	X		
Litter Critters(a)		X	X	X	X		
Mark-Recapture		X	X	X	X		
Mystery Marauders(a)		X	X	X	X		
Chemical Warfare(b)		X		X	X	X	
Wings on Seeds(c)		X		X	X		
Seed Robber Detectives		X	X	X	X		
Impacts of SY Traffic & Decomposers		X	X	X	X	X	X
Acorn Weevils		X	X	X	X		
Size of Nature Preserves		X	X	X	X	X	X
Pollution in Snow(c,d)		X		X	X		X
Animal Antifreeze(a,c)		X		X	X	X	

(a) Inquiries published by OBIS that were used in the Michigan SYEFEST: Outdoor Biology Instructional Strategies, Lawrence Hall of Science, University of California, Berkeley, CA 94720. Delta Education: 5 Hudson Park Drive, Hudson, NH 03051 (603-889-8899).

(b) Modified from an inquiry written by Judy Bramble and Sandra Rode in: Schoolyard Ecology. Published by Missouri Botanical Garden, St. Louis, MO

(c) Inquiry also meets objectives under Strand IV (Michigan Science Content Standards and Working Draft Benchmarks): Use scientific knowledge from the Physical Sciences in real-world contexts.

(d) Inquiry also meets objectives under Strand V (Michigan Science Content Standards and Working Draft Benchemarks): Use scientific knowledge from the Earth and Space Sciences in real-world contexts.

Michigan Content Standards and Draft Benchmarks

Michigan Department of Education
http://cdp.mde.state.mi.us/MCF/ContentStandards/default.html
1998

Science Arts Content Standards: Outline

Strand I. Constructing New Scientific Knowledge

- Standard I.1. Constructing New Scientific Knowledge
  - Elementary 1. Generate reasonable questions about the world based on observation.
  - Elementary 2. Develop solutions to unfamiliar problems through reasoning, observation, and/or experiment.
  - Elementary 3. Manipulate simple mechanical devices and explain how they work.
  - Elementary 4. Use simple measurement devices to make metric measurements.
  - Elementary 5. Develop strategies and skills for information gathering and problem solving.
  - Elementary 6. Construct charts and graphs and prepare summaries of observations.

Strand II. Reflect on the Nature, Adequacy and Connections Across Scientific Knowledge (Reflecting on

Scientific Knowledge)

- Standard II.1. Reflecting on Scientific Knowledge
  - Elementary 1. Develop an awareness of the need for evidence in making decisions scientifically.
  - Elementary 2. Show how science concepts can be interpreted through creative expression such as language arts and fine arts.
  - Elementary 3. Describe ways in which technology is used in everyday life.
  - Elementary 4. Develop an awareness of and sensitivity to the natural world.
  - Elementary 5. Develop an awareness of contributions made to science by people of diverse backgrounds.

Strand III. Using Scientific Knowledge in Life Science

- Standard III. 1. Cells
  - Elementary 1. Describe cells as living systems.
- Standard III. 2. The Organization of Living Things
  - Elementary 1. Compare and classify familiar organisms on the basis of observable characteristics.
  - Elementary 2. Describe vertebrates in terms of observable body parts and characteristics.
  - Elementary 3. Describe the life cycles of familiar organisms.
  - Elementary 4. Compare and contrast food, energy, and environmental needs of selected organisms.
  - Elementary 5. Describe functions of selected seed plant parts.
- Standard III. 3. Heredity
  - Elementary 1. Give evidence that characteristics are passed from parents to young.
- Standard III. 4. Evolution
  - Elementary 1. Explain how fossils provide evidence about the nature of ancient life.
  - Elementary 2. Explain how physical and/or behavioral characteristics of organisms help them to survive in their environments.
- Standard III. 5. Ecosystems
  - Elementary 1. Identify familiar organisms as part of a food chain or food web and describe their feeding relationships within the web.
  - Elementary 2. Explain common patterns of interdependence and inter- relationships of living things.
  - Elementary 3. Describe the basic requirements for all living things to maintain their existence.
  - Elementary 4. Design systems that encourage growing of particular plants or animals.
  - Elementary 5. Describe positive and negative effects of humans on the environment.

Strand IV. Using Scientific Knowledge in Physical Science

Strand V. Using Scientific Knowledge in Earth Science

Top of page | Main appendix List | Back to Appendix 4 | Table of Contents
Help | About IES | Search | Print | Forums | Contact us | Home

Ecology Content Frameworks - Feinsinger

Feinsinger et al's Framework of Ecology Themes for Schoolyard Ecology

Source: Feinsinger, P., A. Grajal and A.R. Berkowitz. 1997. Some themes appropriate for schoolyard ecology and other hands?on ecology education. Bulletin of the Ecological Society of America. 78:144?146.

I. Organisms and Environments: Variation in Space and Time

A. Perception - taking the organism's point of view (or of smell?)

Exploration of this theme is fundamental at any educational level. Observing other organisms (e.g., squirrels, birds, insects, spiders, lizards, vascular plants, fungi), learners try to shed human biases, scales and viewpoints, instead conceptualizing how other living entities perceive and deal with their immediate environment.

B. The non-living environment - viewpoints of plants, animals and microbes.

1. Microhabitats and microclimates - the good, the bad and the nasty (e.g., microclimates that ameliorate average ambient conditions and those that exacerbate them).

2. Patchiness and scale - what's coarse for the grasshopper is just fine for the cow (related to perception but emphasizing heterogeneity and spatial scale).

3. Daily cycles - as different as night and day (e.g., cycles in light regime, temperature, humidity, predation pressure).

4. Annual cycles - to everything a season (e.g., plant phonologies, annual cycles of animals in season environments).

5. History, chance and long-term change - footprints of the past in the schoolyard.

a. The weather in the schoolyard hasn't always been like this (evidence in the school surroundings for historic changes, for example, glacial or lacustrine deposits, fossils sand dunes, impacts of more recent events such as El Nino, hurricanes and ice storms.

b. This hasn't always been a schoolyard (evidence for effects of prehistoric peoples, of European settlement and its aftermath, and of more recent changes in land use patterns).

c. Most of what now lives in the schoolyard used to live somewhere very different (biogeographic and habitat origins of plant and animal populations, for example, Eurasian weeds and house sparrows or immigrants from neighboring ecosystems).

C. Traits of organisms that enhance survival and reproduction - how to make ends meet in your home patch.

1. Finding a mate: birds do it, bees do it, even little weeds do it.

a. plants: (pollination and plant reproductive systems).

b. animals: (behavioral ecology of mating systems).

2. Finding a place to raise young: the kid thrive in some places but not others.

a. plants: (seed germination and dormancy strategies in an environment whose favorableness is patchy in space and time).

b. animals: (nesting, oviposition, host plant choice).

3. Finding food and water: there's no such thing as a free lunch.

a. plants: (e.g., leaf "tactics" with respect to light/moisture regimes, plant life forms as "tactics." Root "tactics." Mutualisms and symbioses such as nitrogen fixation and ant nutrient scroungers).

b. animals: (foraging ecology/behavior and all associated concepts).

c. microbes: ("foraging tactics" of decomposers and disease organisms).

4. Stress reduction: making do when things are tough ("strategies" of plants, animals, and microbes for dealing with stress, for example avoidance, tolerance, surviving unfavorable seasons, or fire-related traits).

D. The consequences of having babies: reproduction and population growth.

1. Changes: what makes populations grow and shrink?

2. Limits: what stops populations from growing forever?

3. Crowds and loners: how are populations patterned across the landscape? (Spatial dispersion patterns, their [proximate] causes and consequences).

4. Moving about: how do individuals, or their babies, get from one patch to another? (Immigration, emigration, dispersal, and dispersal of propagules, for example spiders, burs, and spores).

II. Interactions

A. Interactions between a hungry organism and a food organism that "doesn't want" to be eaten.

1. Animal predators and animal prey: more than just wolves and deer (ecological aspects of interactions between predators and prey interactions or insect parasites and hosts; phenotypic traits related to this interaction, such as behavior, morphology, warning coloration, crypsis, and mimicry).

2. Animal predators and plant prey (seed predation).

3. Vegetarian animals and plants: can fodder fight back? (The ecology of herbivory, particularly by insects; traits of plants that inhibit herbivory, vs. traits of herbivores that enhance fodder finding and utilization).

4. Fodder fights back with a vengeance: recruitment of mercenaries (bellicose or carnivorous insects attracted by extrafloral nectarines or lipid-rich food bodies).

5. Parasites and hosts: just hanging on, or killing me softly? (Parasitic plants such as mistletoe; or botflies, screwworms, ticks, and fleas an domestic animals).

6. Microbes and hosts: is disease just a said effect of "hungry microbes?" (Effects of disease on plants and animals at individual and population levels; the concept of epidemiology).

B. Interactions between a hungry organism and an item that "wants" to be eaten.

1. Flowers and animal flower - visitors.

2. Fleshy fruits and animal fruit eaters.

C. Interactions between a hungry organism and dead things.

1. Detritivores: making dead matter smaller (e.g. the actions and effects of earthworms and arthropod detritivores).

2. Decomposers: making dead matter different (e.g., food preferences among fungi).

D. Interactions between two "hungry" organisms who like the same things (interspecific competition among, for example, ants, flower-visiting insects, insect-visited flowering plants, light and water-seeking plants, or decomposers.

III. Communities and landscapes

A. Some kinds of organisms are more common than others: relative abundance (commonness and rarity, their proximate causes and consequences).

B. Some kinds of habitat have more kinds or organisms than others: relative species richness among sites that differ in various physical or disturbance characteristics, e.g., leaf litter in sun vs. shade, or mowed vs. un-mowed lawn, or north vs. south side of building.)

C. Some patches of the same kind of habitat have more kinds of organisms than others: the influence of size and shape (the concept of "isolates," or circumscribed patches of habitat; species-area relationships and related concepts).

1. "Natural-born patches" (e.g., grass tussocks, thistle plants, or undersides of rocks of different sizes).

2. "Created" patches (habitat fragments).

D. No patch is an island: patches can influence what goes on in each other (edge effects and other themes of landscape ecology).

E. More or less disturbed: some patches are more disturbed than others, and end up hosting different numbers and kinds of organisms (sources and effects of disturbances at various scales and of various intensities).

F. Just after the event: some patches "recover" from being disturbed but others just keep going downhill ("ecological succession" and retrogression or, better, community dynamics).

G. Long after the event: today's patches reflect yesterday's disturbance (history and long-term change with a community and landscape-level perspective).

People are part of the picture, for better or for worse (the various and variable effects of human activities on ecological processes and patterns).

Top of page | Main appendix List | Back to Appendix 4 | Table of Contents
Help | About IES | Search | Print | Forums | Contact us | Home

Help Contact us About IES Search Print options Forums

Handbook Contents

Appendix 4 Schoolyard Ecology Leaders' Handbook

Ecology & inquiry frameworks

Ecological Literacy Framework by Paul Risser

Paul Risser, in his presidential address to the ESA (Risser 1986), proposed a simple framework for ecological literacy for the general public, suggesting that people should understand:

1. Multi-media transport of materials, for example (but not limited to) sources and sinks, bio-magnification and chemical transformations.

2. Just how "everything is connected to everything", i.e., understanding specific instances of connections and the relative strengths of interactions, so that individuals can build their own view of ecological interactivity, incrementally and inductively.

3. Ecology-culture interactions, including economics, application to managing natural resources and interactions between ecology and cultural heritage.

4. Familiar ecological field observations based on learning about a specific, local "spot" in nature, using this as a concrete example of ecological concepts, a site for action and a springboard for understanding and appreciating other "spots."

Risser, P.G. 1986. Ecological Literacy. Address of the Past President, Syracuse, NY; August 1986. Bulletin of the Ecological Society of America 67:264-270.

Appendix 4 Schoolyard Ecology Leaders' Handbook

Ecology & inquiry frameworks

Ecological Literacy Framework by David Orr

Another vision for ecological literacy is given eloquent voice by David Orr (Orr 1992). He argues that the ecologically literate person would have the "capacity to observe nature with insight", being able "... to distinguish between health and disease in natural systems and their relation to health and disease in human ones." Orr puts much emphasis on the importance of building ecological literacy through study and work in your "place" in the natural world, applying a system of education that does not separate the "how" from the "what" of curriculum and teaching. His argument for the need for people who can think broadly, possessing "... that quality of mind that seeks out connections" could present an insurmountable challenge to attempts such as the guidelines project if our definitions remain bounded by disciplines and conventional knowledge. His list of essential concepts provides another alternative framework, positing that the ecologically literate person should understand:

1. The earth as a physical system.
2. Ecology and thermodynamics.
3. The earth's "vital signs."
4. The essentials of human ecology.
5. The natural history of one=s own region.
6. How to restore natural systems and build sustainable communities and economies.

Orr, D.W. 1993. Ecological Literacy. Education and the Transition to a Postmodern World. State University of New York Press. Albany, NY. 210 pages.

Appendix 4 Schoolyard Ecology Leaders' Handbook

Ecology & inquiry frameworks

Framework of Understanding for Ecological Literacy

Source: Berkowitz, A.R., M. Archie and D. Simmons. 1997. Defining environmental literacy: a call for action. Bulletin of the Ecological Society of America. 78:170?172.

I. Understanding the processes of ecological understanding

A. the inquiry process - reflection, question and hypothesis formation, investigation, construction, reflection and application

B. modes of investigation - observation, comparison, experimentation, simulation

C. life-long learning

D. limitations to ecological understanding

E. how to find and get what you need from experts and other sources

II. Key ecological understandings

A. BIG ideas -

1. the Flux of Nature - change, disturbance and recovery are the norms for ecological systems.

2. humans are part of the environment, influencing virtually everything and being influenced by it too.

3. spatial and temporal scales - their diversity, lack of correspondence, and "perception" by different organisms

4. complexity, feedback, hierarchy

5. uncertainty

6. ecological systems are shaped by history and by surrounding systems

B. Individuals, Populations, Communities and Limiting Factors

1. habitats, species' ecological traits, environmental constraints, functional roles of species

2. food chains, food webs, mutualisms

3. population dynamics

4. population and community dynamics

5. biodiversity

C. Ecosystem and Landscapes

1. boundaries, systems, inputs-outputs-storage

2. energy and nutrients

3. landscape ecology

III. Ecological understanding of human existence

A. human needs

B. human resources

C. human impacts

IV. Practical application of the processes and products of ecological understanding

A. understanding your local environment and your role in it

B. understanding your role in the larger environment

C. decision making, problem solving

D. building a sustainable future - i.e., more than just problems, but how to meet

NAAEE Framework for Environmental Literacy

CONTENT STANDARD G:

An important building block in the foundation of environmental literacy is an understanding of the processes and systems that comprise the environment. In addition, environmental literacy depends on an understanding of human processes and systems and their influence on the environment. The guidelines under this theme begin with overarching ideas that are common to the search for knowledge about natural and human systems. Then separate guidelines are specified for the study of natural systems and human systems.

UNDERSTANDING THE ENVIRONMENT:
Basic concepts and approaches

THE NATURE OF SCIENTIFIC UNDERSTANDING

- Science is a social process of building understanding that is ongoing and changing.
- Scientific understanding is built and revised in certain ways.
- Scientific understanding has limits.

UNIFYING CONCEPTS AND PROCESSES

- Systems.
- Interdependence.
- Change and dynamic balance.

KNOWLEDGE OF NATURAL PROCESSES AND SYSTEMS
Knowledge of processes and systems

- Basic insights about the functioning of natural systems (e.g., change, disturbance, recovery, humans are part of the environment, complexity, feedback, and hierarchy, causes and consequences of variability and randomness).
- Physical processes within and among the earth's physical systems: the atmosphere, biosphere, lithosphere, and hydrosphere.
- Individuals, populations, and communities.

- Ecosystems -- the interactions of communities of plants, animals, fungi, protists and bacteria with the other components of the physical environment.
- Ecosystem function (e.g., biotic and abiotic limits to growth, size, and distribution of populations, sources and importance of energy, and transfer and energy flow through living systems, cycling of water, nutrients, and materials).
- Understanding of human dependence on the environment.
- Understanding of humans as an ecological variable.

KNOWLEDGE OF HUMAN PROCESSES AND SYSTEMS

- Understanding of a range of aspects of environmental issues.
- Understanding of what shapes individual and group behavior toward the environment, including knowledge of different cultures' perceptions of humans and the environment.
- Knowledge of human cultural activities and their environmental influence, including the relationships between resources and societies and the environmental impact of global developments.
- Knowledge of how governments make and enforce environmental laws.
- Awareness of inequity.

Inquiries and Metaphors for Ecological Principles

Conceptual Framework for Developing Schoolyard Ecology Questions

Chris Myers, Lead Ecologist, Oxford Ohio SYEFEST. Modified from Peter Feinsinger's Framework. Edited by Alan Berkowitz.

BASES:

- Physical laws apply to organisms, too
- Evolution tends to result in traits that enhance survival and reproduction
- Physical and biological realities impose tradeoffs and constraints on what is possible

I. TAXONOMY AND PHYLOGENY

A. Organisms differ from one another.

B. Similar organisms can be grouped.

C. Patterns of similarities among groups tell us something about how lineages evolve

II. INTERACTION BETWEEN AND INDIVIDUAL AND ITS PHYSICAL ENVIRONMENT

A. Assessing the environment.

B. Physical and physiological traits that help organisms survive in their environment.

C. Behavioral and life-history traits that help organisms survive in their environment (or find a new one).

1. Avoidance (local), migration

2. Homes, habitat selection

III. INTERACTIONS BETWEEN AN INDIVIDUAL AND OTHER INDIVIDUALS (WITHIN AND AMONG SPECIES)

A. Reproduction

1. Plant mating systems and seed dispersal (often = mutualism)

2. Animal mating systems and dispersal

B. Foraging

C. Competition

D. Mutualism

E. Parasitism and disease

F. Communication

IV. A POPULATION PERSPECTIVE

A. Population estimation, growth, regulation, and carrying capacity.

B. Life history variation, life cycles, and dispersal.

V. COMMUNITY PERSPECTIVES: INTEGRATION AND PATTERN AMONG ASSEMBLAGES OF POPULATIONS

A. Species richness, diversity, and dynamics

B. Niche, species packing, and guilds

C. Keystone species

D. Food webs

E. Disturbance and regeneration

VI. ECOSYSTEM AND GLOBAL PERSPECTIVES

A. Ecosystem productivity and biodiversity

B. Flow of materials and energy through an ecosystem

D. Global cycles

VII. VARIATION, CHANGE, CYCLES AND SCALE

A. Variation over time

1. ecological perspectives (succession, diurnal and seasonal changes)
2. evolutionary perspectives (history of life, evolutionary ecology)
3. geologic perspectives (climate change, paleoecology, plate tectonics, animal migrations)

B. Variation over space

1. landcape ecology at micro, meso, regional and global scales
2. biogeography

VIII. HUMANS WITHIN ECOSYSTEMS

A. Stress and disturbance regimes (also resistance and resilience)

B. Conservation and restoration

C. The concepts of biodiversity, sustainability and dependence

D. Knowledge, attitudes, ethics, beliefs and behaviors of different cultures

IX. OBSERVATION, PERCEPTION, IMAGINATION, REVERENCE

Appendix 4 Schoolyard Ecology Leaders' Handbook

Ecology & inquiry frameworks

Ecology Content Frameworks - Logan, Utah

Teachers participating in the Logan, Utah, SYEFEST generated a short list of key concepts that they deemed suitable for schoolyard ecology teaching, using the acronym I.D.E.A.S. For each concept, they listed some of the important ideas involve (in italics), and identified activities that could be used to address the concept.

I.D.E.A.S.: Primary Ecology Concepts

Interdependence

symbiosis, limits, environments

Activities: Good Buddies

Diversity

genetic, species, system, habitats

Activities: use the idea of a scavenger hunt for any core objective, map the schoolyard with respect to habitats or species present, make up a key or use a key to classify plants on the schoolyard.

Ever-lasting

disturbance, succession, energy-flow, cycles

Activities: soil compaction, playing lightly, plant time travel

Adaptation

stress/response, traits, process

Activities: fly a leaf, leaf toughness, moisture makers

Systems

Communities, environment, populations

Activities: microhabitat, beautiful basics, habitat lap sit - then modify by asking them to think about what lives on the schoolyard and the needs of those organisms (journal entry regarding the needs of a schoolyard inhabitant and the impact of kids)

Appendix 4 Schoolyard Ecology Leaders' Handbook

Ecology & inquiry frameworks

What Should Students Understand About Scientific Inquiry?

Grades K-4

- Scientific investigations involve asking and answering a question and comparing the answer with what scientists already know about the world. [See Content Standard G (grades K-4)]
- Scientists use different kinds of investigations depending on the questions they are trying to answer. Types of investigations include describing objects, events, and organisms; classifying them; and doing a fair test (experimenting).
- Simple instruments, such as magnifiers, thermometers, and rulers, provide more information than scientists obtain using only their senses. **[See Program Standard C]**
- Scientists develop explanations using observations (evidence) and what they already know about the world (scientific knowledge). Good explanations are based on evidence from investigations.
- Scientists make the results of their investigations public; they describe the investigations in ways that enable others to repeat the investigations.
- Scientists review and ask questions about the results of other scientists' work.

Grades 5-8

- Different kinds of questions suggest different kinds of scientific investigations. Some investigations involve observing and describing objects, organisms, or events; some involve collecting specimens; some involve experiments; some involve seeking more information; some involve discovery of new objects and phenomena; and some involve making models.
- Current scientific knowledge and understanding guide scientific investigations. Different scientific domains employ different methods, core theories, and standards to advance scientific knowledge and understanding.
- Mathematics is important in all aspects of scientific inquiry.
- Technology used to gather data enhances accuracy and allows scientists to analyze and quantify results of investigations.
- Scientific explanations emphasize evidence, have logically consistent arguments, and use scientific principles, models, and theories. The scientific community accepts and uses such explanations until displaced by better scientific ones. When such displacement occurs, science advances.
- Science advances through legitimate skepticism. Asking questions and querying other scientists' explanations is part of scientific inquiry. Scientists evaluate the explanations proposed by other scientists by examining evidence, comparing evidence, identifying faulty reasoning, pointing out statements that go beyond the evidence, and suggesting alternative explanations for the same observations.
- Scientific investigations sometimes result in new ideas and phenomena for study, generate new methods or procedures for an investigation, or develop new technologies to improve the collection of data. All of these results can lead to new investigations.

Grades 9-12

- Scientists usually inquire about how physical, living, or designed systems function. Conceptual principles and knowledge guide scientific inquiries. Historical and current scientific knowledge influence the design and interpretation of investigations and the evaluation of proposed explanations made by other scientists. **[See Unifying Concepts and Processes]**

- Scientists conduct investigations for a wide variety of reasons. For example, they may wish to discover new aspects of the natural world, explain recently observed phenomena, or test the conclusions of prior investigations or the predictions of current theories.
- Scientists rely on technology to enhance the gathering and manipulation of data. New techniques and tools provide new evidence to guide inquiry and new methods to gather data, thereby contributing to the advance of science. The accuracy and precision of the data, and therefore the quality of the exploration, depends on the technology used. **[Content Standard E (grades 9-12)]**
- Mathematics is essential in scientific inquiry. Mathematical tools and models guide and improve the posing of questions, gathering data, constructing explanations and communicating results. **[See Program Standard C]**
- Scientific explanations must adhere to criteria such as: a proposed explanation must be logically consistent; it must abide by the rules of evidence; it must be open to questions and possible modification; and it must be based on historical and current scientific knowledge.
- Results of scientific inquiry--new knowledge and methods--emerge from different types of investigations and public communication among scientists. In communicating and defending the results of scientific inquiry, arguments must be logical and demonstrate connections between natural phenomena, investigations, and the historical body of scientific knowledge. In addition, the methods and procedures that scientists used to obtain evidence must be clearly reported to enhance opportunities for further investigation.

Top of page | Main appendix List | Back to Appendix 4 | Table of Contents
Help | About IES | Search | Print | Forums | Contact us | Home

Appendix 4 Schoolyard Ecology Leaders' Handbook

Ecology & inquiry frameworks

What Abilities are Necessary to do Scientific Inquiry?

Grades K-4

- Ask a question about objects, organisms, and events in the environment.
- Plan and conduct a simple investigation.
- Employ simple equipment and tools to gather data and extend the senses.
- Use data to construct a reasonable explanation.
- Communicate investigations and explanations.

Grades 5-8

- Identify questions that can be answered through scientific investigations.
- Design and conduct a scientific investigation.
- Use appropriate tools and techniques to gather, analyze, and interpret data.
- Develop descriptions, explanations, predictions, and models using evidence.
- Think critically and logically to make the relationships between evidence and explanations.
- Recognize and analyze alternative explanations and predictions.
- Communicate scientific procedures and explanations.
- Use mathematics in all aspects of scientific inquiry.

Grades 9-12

- Identify questions and concepts that guide scientific investigations.
- Design and conduct scientific investigations.
- Use technology and mathematics to improve investigations and communications.
- Formulate and revise scientific explanations and models using logic and evidence.
- Recognize and analyze alternative explanations and models.
- Communicate and defend a scientific argument.

Appendix 4 Schoolyard Ecology Leaders' Handbook

Ecology & inquiry frameworks

Standards for Professional Development of Teachers of Science

The first three professional development standards can be summarized as learning science, learning to teach science, and learning to learn. The fourth standard addresses the characteristics of quality professional development programs at all levels.

PROFESSIONAL DEVELOPMENT STANDARD A:

Professional development for teachers of science requires learning essential science content through the perspectives and methods of inquiry. Science learning experiences for teachers must

- Involve teachers in actively investigating phenomena that can be studied scientifically, interpreting results, and making sense of findings consistent with currently accepted scientific understanding.
- Address issues, events, problems, or topics significant in science and of interest to participants.
- Introduce teachers to scientific literature, media, and technological resources that expand their science knowledge and their ability to access further knowledge.
- Build on the teacher's current science understanding, ability, and attitudes.
- Incorporate ongoing reflection on the process and outcomes of understanding science through inquiry.
- Encourage and support teachers in efforts to collaborate.

PROFESSIONAL DEVELOPMENT STANDARD B:

Professional development for teachers of science requires integrating knowledge of science, learning, pedagogy, and students; it also requires applying that knowledge to science teaching. Learning experiences for teachers of science must

- Connect and integrate all pertinent aspects of science and science education.
- Occur in a variety of places where effective science teaching can be illustrated and modeled, permitting teachers to struggle with real situations and expand their knowledge and skills in appropriate contexts.
- Address teachers' needs as learners and build on their current knowledge of science content, teaching, and learning.
- Use inquiry, reflection, interpretation of research, modeling, and guided practice to build understanding and skill in science teaching.

PROFESSIONAL DEVELOPMENT STANDARD C:

Professional development for teachers of science requires building understanding and ability for lifelong learning. Professional development activities must

- Provide regular, frequent opportunities for individual and collegial examination and reflection on classroom and institutional practice.
- Provide opportunities for teachers to receive feedback about their teaching and to understand, analyze, and apply that feedback to improve their practice.

- Provide opportunities for teachers to learn and use various tools and techniques for self-reflection and collegial reflection, such as peer coaching, portfolios, and journals.
- Support the sharing of teacher expertise by preparing and using mentors, teacher advisers, coaches, lead teachers, and resource teachers to provide professional development opportunities.
- Provide opportunities to know and have access to existing research and experiential knowledge.
- Provide opportunities to learn and use the skills of research to generate new knowledge about science and the teaching and learning of science.

PROFESSIONAL DEVELOPMENT STANDARD D:

Professional development programs for teachers of science must be coherent and integrated. Quality preservice and inservice programs are characterized by

- Clear, shared goals based on a vision of science learning, teaching, and teacher development congruent with the National Science Education Standards .
- Integration and coordination of the program components so that understanding and ability can be built over time, reinforced continuously, and practiced in a variety of situations.
- Options that recognize the developmental nature of teacher professional growth and individual and group interests, as well as the needs of teachers who have varying degrees of experience, professional expertise, and proficiency.
- Collaboration among the people involved in programs, including teachers, teacher educators, teacher unions, scientists, administrators, policy makers, members of professional and scientific organizations, parents, and business people, with clear respect for the perspectives and expertise of each.
- Recognition of the history, culture, and organization of the school environment.
- Continuous program assessment that captures the perspectives of all those involved, uses a variety of strategies, focuses on the process and effects of the program, and feeds directly into program improvement and evaluation.