EARTH/ENVIRONMENTAL SCIENCE

Goals

The Earth/Environmental science curriculum focuses on the function of Earth's systems. Emphasis is placed on matter, energy, plate tectonics, origin and evolution of the earth and solar system, environmental awareness, materials availability, and the cycles that circulate energy and material through the earth system. This section introduces teachers to the program strands and unifying concepts. During instruction, these concepts should be woven through the content goals and objectives of the course. Supplemental materials providing a more detailed explanation of the goals, objectives, and strands, with specific recommendations for classroom and/or laboratory implementation are available through the Department of Public Instruction's Publications Section.

Unifying Concepts

The following unifying concepts should unite the study of various Earth and environmental topics across grade levels.

- Systems, Order and Organization.
- Evidence, Models, and Explanation.
- Constancy, Change, and Measurement.
- Evolution and Equilibrium.
- Form and Function.

Nature of Science

This strand is divided into three sections: Science as a human endeavor, historical perspectives, and the nature of scientific inquiry. These sections are designed to help students understand the human dimensions of science, the nature of scientific thought, and the role of science in society. The earth and environmental sciences are rich in examples of science as a human endeavor, its historical perspectives, and the development of scientific understanding.

Science as a Human Endeavor

Intellectual honesty and an ethical tradition are hallmarks of the practice of science. The practice is rooted in accurate data reporting, peer review, and making findings public. This aspect of the nature of science can be taught by designing instruction that encourages students to work collaboratively in groups to design investigations, formulate hypotheses, collect data, reach conclusions, and present their findings to their classmates.

The content studied in Earth/Environmental science is an opportunity to present science as the basis for civil engineering, mining, geology, oceanography, astronomy, and the environmental technical trades. The content diversity lets us look at science as a vocation. Scientist and technician are just two of the many careers in which an earth and environmental sciences background is necessary.

Perhaps the most important aspect of this strand is that science is an integral part of society and is therefore relevant to students' lives.

Historical Perspectives

Most scientific knowledge and technological advances develop incrementally from the labors of scientists and inventors. Although science history includes accounts of serendipitous scientific discoveries, most development of scientific concepts and technological innovation occurs in response to a specific problem or conflict. Both great advances and gradual knowledge building in science and technology have profound effects on society. Students should appreciate the scientific thought and effort of the individuals who contributed to these advances. Some examples are Eratosthenes' determination of the size of the earth, Wegener's apparent "fit" of the continents, Kepler's laws of planetary motion, and James Hutton's simple yet powerful idea that Earth's history must be explained by what we see happening now. Today, Hutton's uniformity of process principle is used to interpret the structure of landing sites on Mars.

Nature of Scientific Knowledge

Much of what is understood about the nature of science must be explicitly addressed:

- All scientific knowledge is tentative, although many ideas have stood the test of time and are reliable for our use.
- Theories "explain" phenomena that we observe. They are never proved; rather, they represent the most logical explanation based on currently available evidence. Theories become stronger as more supporting evidence is gathered. They may be modified as new data is gathered or existing data is interpreted in different ways. They provide a context

for further research and give us a basis for prediction. For example, the Theory of Plate Tectonics explains the movement of lithospheric plates.

- Laws are fundamentally different from theories. They are universal generalizations based on observations of the natural world, such as the nature of gravity, the relationship of forces and motion, and the nature of planetary movement.
- Scientists, in their quest for the best explanations of natural phenomena, employ rigorous methods. Scientific explanations must adhere to the rules of evidence, make predictions, be logical, and be consistent with observations and conclusions. "Explanations of how the natural world changes based on myths, personal beliefs, religious values, mystical inspiration, superstition, or authority may be personally useful and socially relevant, but they are not scientific." (National Science Education Standards, 1996, p. 201)

Science as Inquiry

Inquiry should be the central theme in earth/environmental science. It is an integral part of the learning experience and may be used in both traditional class problems and laboratory experiences. The essence of the inquiry process is to ask questions that stimulate students to think critically and to formulate their own questions. Observing, classifying, using numbers, plotting graphs, measuring, inferring, predicting, formulating models, interpreting data, hypothesizing, and experimenting help students build knowledge and communicate what they have learned. Inquiry applies creative thinking to new and unfamiliar situations. Students should learn to design solutions to problems that interest them. This may be accomplished in a variety of ways, but situations that present a discrepant event or ones that challenge students' intuitions have been successful. For example, traditional labs, which emphasize observation of the sun or identification and classification of sediments, may be quite appropriate. These labs should, however, lead to open-ended explorations such as investigation of sun spot activity or the factors that influence the sorting of sediments. Although original student research has often been relegated to a yearly science fair project, continuing student research contributes immensely to understanding of the process of science and to problem-solving abilities. Earth/Environmental science provides many opportunities for inquiry. "Why does the location of sunrise or sunset change through the year?" "Why are sedimentary rock layers tipped at an angle?" "Why do sunspots move faster near the sun's equator?" The processes of inquiry, experimental design, investigation, and analysis are as important as finding the correct answer. Students will acquire much more than facts and manipulative skills; they will learn to be critical thinkers.

A solid conceptual base of scientific principles, as well as knowledge of science safety is necessary for inquiry. Students should be given a supportive learning environment based on how scientists and engineers work. Adherence to all science safety criteria and guidelines for classroom, field, and laboratory experiences is imperative. Contact the Science Section at DPI for information and professional development opportunities regarding North Carolina specific Science Safety laws, codes, and standards. The Science Section is spearheading a statewide initiative entitled *NC-The Total Science Safety System*.

Science And Technology

It is impossible to learn science without developing some appreciation of technology. Therefore, this strand has a dual purpose: (a) developing students' knowledge and skills in technological design, and (b) enhancing their understanding of science and technology. The methods of scientific inquiry and technological design share many common elements - objectivity, clear definition of the problem, identification of goals, careful collection of observations and data, data analysis, replication of results, and peer review. Technological design differs from inquiry in that it must operate within the limitations of materials, scientific laws, economics, and the demands of society. Together, science and technology present many solutions to problems of survival and enhance the quality of life. Technological design plays an important role in earth/environmental science. For example, telescopes, lasers, satellites, transistors, graphing calculators, personal computers, and seismographs have changed our lives, increased our knowledge of earth/environmental science, and improved our understanding of the universe.

Science in Personal and Social Perspectives

This strand helps students formulate a basic understanding of and implied actions for many issues facing our society. The fundamental concepts that form the basis for this strand include:

- Environmental Quality - Students should develop an appreciation for factors that influence their need and responsibility to maintain environmental quality, including waste disposal and recycling of limited natural resources. The ability to make appropriate decisions based on cost-benefit and risk analysis is an integral part of the study of earth and environmental science. "Many factors influence environmental quality. Factors that students might investigate include population growth, resource use, population distribution, over-consumption, the capacity of technology to solve problems, poverty, the role of economic, political, and religious views, and different ways humans view the earth." (National Science Education Standards, 1996, p. 198).
- Natural and Human -Induced Hazards - The study of earth and environmental science encourages students to investigate the effects of natural phenomena and human induced changes in natural systems on society. Appropriate examples include natural phenomena such as earthquakes and human-induced changes such as increased carbon dioxide in the atmosphere. Students will acquire the ability to assess natural and human induced hazards - ranging from relatively minor risks to catastrophic events with major risk, as well as the accuracy with which these events can be predicted. It is particularly important for students to relate such phenomena to North Carolina and its citizens.
- Science and Technology in Local, National, and Global Challenges - Along with the need to understand the causes and extent of environmental challenges related to natural and man-made phenomena, students should become familiar with the advances proper application of scientific principles and products have brought to environmental enhancements. Topics such as improved energy use, reduced vehicle emissions, and improved crop yields are just some examples of how the proper application of science has improved the quality of life. This strand will help students make rational decisions in the use of

scientific and technological knowledge. "Understanding basic concepts and principles of science and technology should precede active debate about the economics, policies, politics, and ethics of various science and technology-related challenges. However, understanding science alone will not resolve local, national, or global challenges." (NSES, 1996, p. 199). The *NSES* emphasize that students should understand the appropriateness and value of basic questions 'What can happen?' - 'What are the odds?' - and 'How do scientists and engineers know what will happen?'" (NSES, 1996, p. 199).

EARTH/ENVIRONMENTAL SCIENCE Grades 9-12

The Earth/Environmental science curriculum focuses on the function of Earth's systems. Emphasis is placed on matter, energy, plate tectonics, environmental awareness, materials availability, and the cycles that circulate energy and material through the earth system. Learners will study natural and technological systems. The program strands and unifying concepts provide a context for teaching content and process skill goals. All goals should focus on the unifying concepts:

- Systems, Order and Organization
- Evidence, Models, and Explanation
- Constancy, Change, and Measurement
- Evolution and Equilibrium
- Form and Function

Strands: The strands are: Nature of Science, Science as Inquiry, Science and Technology, Science in Personal and Social Perspectives. They provide the context for teaching of the content Goals and Objectives.

COMPETENCY GOAL 1: The learner will develop abilities necessary to do and understand scientific inquiry in the earth and environmental sciences.

Objectives

1.01 Identify questions and problems in the earth and environmental sciences that can be answered through scientific investigations.

1.02 Design and conduct scientific investigations to answer questions related to earth and environmental science.
- Create testable hypotheses
- Identify variables.
- Use a control or comparison group when appropriate.
- Select and use appropriate measurement tools.
- Collect and record data.
- Organize data into charts and graphs.
- Analyze and interpret data.
- Communicate findings.

1.03 Evaluate the uses of satellite images and imaging techniques in the earth and environmental sciences.

1.04 Apply safety procedures in the laboratory and in field studies:
- Recognize and avoid potential hazards.
- Safely manipulate materials and equipment needed for scientific investigations.

1.05 Analyze reports of scientific investigations and environmental issues from an informed scientifically literate viewpoint including considerations of:
- Appropriate sample.
- Adequacy of experimental controls.
- Replication of findings.
- Alternative interpretations of the data.

1.06 Identify and evaluate a range of possible solutions to earth and environmental issues at the local, national, and global level including considerations of:
- Interdependent human and natural systems.
- Diverse perspectives.
- Short and long range impacts.
- Economic development, environmental quality and sustainability.
- Opportunities for and consequences of personal decisions.
- Risks and benefits of technological advances.

COMPETENCY GOAL 2: The learner will build an understanding of lithospheric materials, tectonic processes, and the human and environmental impacts of natural and human-induced changes in the lithosphere.

Objectives

2.01 Analyze the dependence of the physical properties of minerals on the arrangement and bonding of their atoms.

2.02 Analyze the historical development of the theory of plate tectonics.

2.03 Investigate and analyze the processes responsible for the rock cycle:
- Analyze the origin, texture and mineral composition of rocks.
- Trace the path of elements through the rock cycle.
- Relate rock formation to plate tectonics.
- Identify forms of energy that drive the rock cycle.
- Analyze the relationship between the rock cycle and processes in the atmosphere and hydrosphere.

2.04 Analyze seismic waves including velocity and refraction to:
- Infer Earth's internal structure.
- Locate earthquake epicenters.
- Measure earthquake magnitude.
- Evaluate the level of seismic activity in North Carolina.

2.05 Create and interpret topographic, soil and geologic maps using scale and legends.

2.06 Investigate and analyze the importance and impact of the economic development of earth's finite rock, mineral, soil, fossil fuel and other natural resources to society and our daily lives:
- Availability.
- Geographic distribution.
- Conservation/Stewardship.
- Recycling.
- Environmental impact.
- Challenge of rehabilitation of disturbed lands.

2.07 Analyze the sources and impacts of society's use of energy.
- Renewable and non-renewable sources.
- The impact of human choices on Earth and its systems.

COMPETENCY GOAL 3: The learner will build an understanding of the origin and evolution of the earth system.

Objectives

3.01 Assess evidence to interpret the order and impact of events in the geologic past:
- Relative and absolute dating techniques.
- Statistical models of radioactive decay.
- Fossil evidence of past life.
- Uniformitarianism.
- Stratigraphic principles.
- Divisions of Geologic Time
- Origin of the earth system.
- Origin of life.

3.02 Evaluate the geologic history of North Carolina.

COMPETENCY GOAL 4: The learner will build an understanding of the hydrosphere and its interactions and influences on the lithosphere, the atmosphere, and environmental quality.

Objectives

4.01 Evaluate erosion and depositional processes:
- Formation of stream channels with respect to the work being done by the stream (i.e. down-cutting, lateral erosion, and transportation).
- Nature and characteristics of sediments.
- Effects on water quality.
- Effect of human choices on the rate of erosion.

4.02 Analyze mechanisms for generating ocean currents and upwelling:
- Temperature.
- Coriolis effect.
- Climatic influence.

4.03 Analyze the mechanisms that produce the various types of shorelines and their resultant landforms:
- Nature of underlying geology.
- Long and short term sea-level history.
- Formation and breaking of waves on adjacent topography.
- Human impact.

4.04 Evaluate water resources:
- Storage and movement of groundwater.
- Ecological services provided by the ocean
- Environmental impacts of a growing human population.
- Causes of natural and manmade contamination.

4.05 Investigate and analyze environmental issues and solutions for North Carolina's river basins, wetlands, and tidal environments:
- Water quality.
- Shoreline changes.
- Habitat preservation.

COMPETENCY GOAL 5: The learner will build an understanding of the dynamics and composition of the atmosphere and its local and global processes influencing climate and air quality.

Objectives

5.01 Analyze air masses and the life cycle of weather systems:
- Planetary wind belts.
- Air masses.
- Frontal systems.
- Cyclonic systems.

5.02 Evaluate meteorological observing, analysis, and prediction:
- Worldwide observing systems.
- Meteorological data depiction.

5.03 Analyze global atmospheric changes including changes in CO_2, CH_4, and stratospheric O_3 and the consequences of these changes:
- Climate change.
- Changes in weather patterns.
- Increasing ultraviolet radiation.
- Sea level changes.

COMPETENCY GOAL 6: The learner will acquire an understanding of the earth in the solar system and its position in the universe.

Objectives

6.01 Analyze the theories of the formation of the universe and solar system.

6.02 Analyze planetary motion and the physical laws that explain that motion:
- Rotation.
- Revolution.
- Apparent diurnal motions of the stars, sun and moon.
- Effects of the tilt of the earth's axis.

6.03 Examine the sources of stellar energies.
- Life cycle of stars.
- Hertzsprung – Russell Diagram.

6.04 Assess the spectra generated by stars and our sun as indicators of motion and composition (the Doppler effect).

6.05 Evaluate astronomers' use of various technologies to extend their senses:
- Optical telescopes.
- Cameras.
- Radio telescopes.
- Spectroscope.