2009 Massachusetts Science and Mathematics Frameworks addressed in Harvard Forest's Schoolyard Ecology Projects*

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I. *Massachusetts Science and Technology/Engineering Curriculum Framework*.
October 2006. Massachusetts Department of Education.

Learning Standards that apply to Harvard Forest schoolyard projects:

Earth and Space Science-Grades PreK-2

The Weather

3. Describe the weather changes from day to day and over the seasons.

The Sun as a Source of Light and Heat

4. Recognize that the sun supplies heat and light to the earth and is necessary for life.

Periodic Phenomena

5. Identify some events around us that have repeating patterns, including the seasons of the year, day and night.

Earth and Space Science-Grades 3-5

The Weather

6. Explain how air temperature, moisture, wind speed and direction, and precipitation make up the weather in a particular place and time.

9. Differentiate between weather and climate

The Water Cycle

10. Describe how water on earth cycles in different forms and in different locations, including underground and in the atmosphere.

11. Give examples of how the cycling of water, both in and out of the atmosphere, has an effect on climate.

Earth and Space Science-Grades 5-8

Heat Transfer in the Earth System

4. Explain the relationship among the energy provided by the sun, the global patterns of atmospheric movement, and the temperature differences among water, land, and atmosphere.

The Earth in the Solar System

11. Explain how the tilt of the earth and its revolution around the sun result in an uneven heating of the earth, which in turn causes the seasons.

Earth and Space Science-High School

Matter and Energy in the Earth System
1.5 Explain how the revolution of Earth around the Sun and the inclination of Earth on its axis cause Earth's seasonal variations (equinoxes and solstices).
1.8 Read, interpret, and analyze a combination of ground-based observations, satellite data, and computer models to demonstrate Earth systems and their interconnections.
3. Earth Processes and Cycles (cont.)
3.4 Explain how water flows into and through a watershed. Explain the roles of aquifers, wells, porosity, permeability, water table, and runoff.
3.5 Describe the processes of the hydrologic cycle, including evaporation, condensation, precipitation, surface runoff and groundwater percolation, infiltration, and transpiration.

II. SCIENTIFIC INQUIRY SKILLS STANDARDS

Scientific literacy can be achieved as students inquire about geologic, meteorological, oceanographic, and astronomical phenomena. The curriculum should include substantial hands-on laboratory and field experiences, as appropriate, for students to develop and use scientific skills in Earth and Space Science, including reading and interpreting maps, keys, and satellite, radar, and telescope imageries; using satellite and radar images and weather maps to illustrate weather forecasts; using seismic data to identify regions of seismic activity; and using data from various instruments that are used to study deep space and the solar system, as well as the inquiry skills listed below.

SIS1. Make observations, raise questions, and formulate hypotheses.

- Observe the world from a scientific perspective.
- Pose questions and form hypotheses based on personal observations, scientific articles, experiments, and knowledge.
- Read, interpret, and examine the credibility and validity of scientific claims in different sources of information, such as scientific articles, advertisements, or media stories.

SIS2. Design and conduct scientific investigations.

- Articulate and explain the major concepts being investigated and the purpose of an investigation.
- Select required materials, equipment, and conditions for conducting an experiment.
- Identify independent and dependent variables.
- Write procedures that are clear and replicable.

- Employ appropriate methods for accurately and consistently
  - making observations
  - making and recording measurements at appropriate levels of precision
  - collecting data or evidence in an organized way
- Properly use instruments, equipment, and materials (e.g., scales, probeware, meter sticks, microscopes, computers) including set-up, calibration (if required), technique, maintenance, and storage.
- Follow safety guidelines.

SIS3. Analyze and interpret results of scientific investigations.

- Present relationships between and among variables in appropriate forms.
- Represent data and relationships between and among variables in charts and graphs.
- Use appropriate technology (e.g., graphing software) and other tools.
- Use mathematical operations to analyze and interpret data results.
- Assess the reliability of data and identify reasons for inconsistent results, such as sources of error or uncontrolled conditions.
- Use results of an experiment to develop a conclusion to an investigation that addresses the initial questions and supports or refutes the stated hypothesis.
- State questions raised by an experiment that may require further investigation.

SIS4. Communicate and apply the results of scientific investigations.

- Develop descriptions of and explanations for scientific concepts that were a focus of one or more investigations.
- Review information, explain statistical analysis, and summarize data collected and analyzed as the result of an investigation.
- Explain diagrams and charts that represent relationships of variables.
- Construct a reasoned argument and respond appropriately to critical comments and questions.
- Use language and vocabulary appropriately, speak clearly and logically, and use appropriate technology (e.g., presentation software) and other tools to present findings.
- Use and refine scientific models that simulate physical processes or phenomena.

Life Science (Biology) –Grades PreK-2

Characteristics of Living Things

1. Recognize that animals (including humans) and plants are living things that grow, reproduce, and need food, air, and water.

2. Differentiate between living and nonliving things. Group both living and nonliving things according to the characteristics that they share.

3. Recognize that plants and animals have life cycles, and that life cycles vary for different living things.

Living Things and Their Environment

7. Recognize changes in appearance that animals and plants go through as the seasons change.

8. Identify the ways in which an organism's habitat provides for its basic needs (plants require air, water, nutrients, and light; animals require food, water, air, and shelter

Life Science (Biology), Grades 3–5

Characteristics of Plants and Animals

1. Classify plants and animals according to the physical characteristics that they share.

Structures and Functions

2. Identify the structures in plants (leaves, roots, flowers, stem, bark, wood) that are responsible for food production, support, water transport, reproduction, growth, and protection.

3. Recognize that plants and animals go through predictable life cycles that include birth, growth, development, reproduction, and death.

Adaptations of Living Things

7. Give examples of how changes in the environment (drought, cold) have caused some plants and animals to die or move to new locations (migration).

9. Recognize plant behaviors, such as the way seedlings' stems grow toward light and their roots grow downward in response to gravity. Recognize that many plants and animals can survive harsh environments because of seasonal behaviors, e.g., in winter, some trees shed leaves, some animals hibernate, and other animals migrate.

Give examples of how organisms can cause changes in their environment to ensure survival. Explain how some of these changes may affect the ecosystem.

Energy and Living Things

10. Describe how energy derived from the sun is used by plants to produce sugars (photosynthesis) and is transferred within a food chain from producers (plants) to consumers to decomposers.

Life Science (Biology), Grades 6-8

Evolution and Biodiversity

10. Give examples of ways in which genetic variation and environmental factors are causes of evolution and the diversity of organisms

12. Relate the extinction of species to a mismatch of adaptation and the environment.

Living Things and Their Environment

13. Give examples of ways in which organisms interact and have different functions within an ecosystem that enable the ecosystem to survive

Energy and Living Things

16. Recognize that producers (plants that contain chlorophyll) use the energy from sunlight to make sugars from carbon dioxide and water through a process called photosynthesis. This food can be used immediately, stored for later use, or used by other organisms.

Changes in Ecosystems Over Time

17. Identify ways in which ecosystems have changed throughout geologic time in response to physical conditions, interactions among organisms, and the actions of humans. Describe how changes may be catastrophes such as volcanic eruptions or ice storms.

18. Recognize that biological evolution accounts for the diversity of species developed through gradual processes over many generations.

Biology, High School

5. Evolution and Biodiversity
    5.2   Describe species as reproductively distinct groups of organisms. Recognize that species are further classified into a hierarchical taxonomic system (kingdom, phylum, class, order, family, genus, species) based on morphological, behavioral, and molecular similarities. Describe the role that geographic isolation can play in speciation.

6. Ecology
Central Concept: Ecology is the interaction among organisms and between organisms and their environment.

    6.1   Explain how birth, death, immigration, and emigration influence population size.
    6.2   Analyze changes in population size and biodiversity (speciation and extinction) that result from the following: natural causes, changes in climate, human activity, and the introduction of invasive, non-native species.
    6.3   Use a food web to identify and distinguish producers, consumers, and decomposers, and explain the transfer of energy through trophic levels. Describe how relationships among organisms (predation, parasitism, competition, commensalism, mutualism) add to the complexity of biological communities.
    6.4   Explain how water, carbon, and nitrogen cycle between abiotic resources and organic matter in an ecosystem, and how oxygen cycles through photosynthesis and respiration.

II. Scientific Inquiry Skills Standards (all aspects of Biology Inquiry skills are addressed in HF-sLTER projects as seen in description for Earth and Space science)**.**

Scientific literacy can be achieved as students inquire about the biological world. The curriculum should include substantial hands-on laboratory and field experiences, as appropriate, for students to develop and use scientific skills in biology, along with the inquiry skills listed below.

II. <u>Mathematics Curriculum Framework</u>

Number Sense and Operations-

Grades 1–2

Identify and represent common fractions (1/2, 1/3, 1/4) as parts of wholes, parts of groups, and numbers on the number line. ▫

Compare whole numbers using terms and symbols, e.g., less than, equal to, greater than (<, =, >). ▫

Grades 3–4

4.N.1 Demonstrate an understanding of fractions as parts of unit wholes, as parts of a collection, and as locations on the number line. ▫

Grades 5–6

-Demonstrate an understanding of fractions as a ratio of whole numbers, as parts of unit whole

Patterns, Relations, and Algebra-

Grades PreK-K

K.P.1 Sort and classify objects by color, shape, size, number, and other properties. ▫

Measurement

K.M.1 Recognize and compare the attributes of length, volume/capacity, weight, area, and time using appropriate language, e.g., longer, taller, shorter, same length; heavier, lighter, same weight; holds more, holds less, holds the same amount. ▫

Exploratory Concepts and Skills
✓ Explore and use standard units to measure and compare temperature, length, and time.
✓ Identify positions of events over time, e.g., earlier, later.

Grades 1–2
-Measure and compare common objects using metric and English units of length measurement, e.g., centimeter, inch.

-Select and correctly use the appropriate measurement tools, e.g. ruler, balance scale, thermometer.

Exploratory Concepts and Skills

✓ Explore measurable attributes of objects, including length, perimeter, weight, area, volume, and temperature. Compare concrete objects using these measures.

✓
✓ **Grades 3–4**
✓ Demonstrate an understanding of such attributes as length, area, weight, and volume, and select the appropriate type of unit for measuring each attribute. ⌨
✓ Identify and use appropriate metric and English units and tools (e.g., ruler, angle ruler, graduated cylinder, thermometer) to estimate, measure, and solve problems involving length, area, volume, weight, time, angle size, and temperature. ●

Data Analysis, Statistics, and Probability

Grades 1–2
Students engage in problem solving, communicating, reasoning, connecting, and representing as they:

2.D.1 Use interviews, surveys, and observations to gather data about themselves and their surroundings. ⌨

2.D.2 Organize, classify, represent, and interpret data using tallies, charts, tables, bar graphs, pictographs, and Venn diagrams; interpret the representations. ●

2.D.3 Formulate inferences (draw conclusions) and make educated guesses (conjectures) about a situation based on information gained from data. ⬥

2.D.4 Decide which outcomes of experiments are most likely. ■

Grades 3–4
Students engage in problem solving, communicating, reasoning, connecting, and representing as they:

4.D.1 Collect and organize data using observations, measurements, surveys, or experiments, and identify appropriate ways to display the data. ⌨

4.D.2 Match a representation of a data set such as lists, tables, or graphs (including circle graphs) with the actual set of data. ●

4.D.3 Construct, draw conclusions, and make predictions from various representations of data sets, including tables, bar graphs, pictographs, line graphs, line plots, and tallies. ⬥

Grades 5–6

6.D.1 Construct and interpret stem-and-leaf plots, line plots, and circle graphs. ●

6.D.2 Use tree diagrams and other models (e.g., lists and tables) to represent possible or actual outcomes of trials. Analyze the outcomes. ■

Exploratory Concepts and Skills

✓ Select, create, and use appropriate graphical representations of data, including histograms, box plots, and scatter plots.
✓ Compare different representations of the same data and evaluate how well each representation shows important aspects of the data.

Grades 7–8

Patterns, Relations, and Algebra

8.P.1 Use tables and graphs to represent and compare linear growth patterns. In particular, compare rates of change and x- and y-intercepts of different linear patterns.

Data Analysis, Statistics, and Probability

Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them Select and use appropriate statistical methods to analyze data Develop and evaluate inferences and predictions that are based on data Understand and apply basic concepts of probability

8.D.1 Describe the characteristics and limitations of a data sample. Identify different ways of selecting a sample, e.g., convenience sampling, responses to a survey, random sampling.
8.D.2 Select, create, interpret, and utilize various tabular and graphical representations of data, e.g., circle graphs, Venn diagrams, scatterplots, stem-and-leaf plots, box-and-whisker plots, histograms, tables, and charts. Differentiate between continuous and discrete data and ways to represent them.

8.D.3 Find, describe, and interpret appropriate measures of central tendency (mean, median, and mode) and spread (range) that represent a set of data. Use these notions to compare different sets of data.

Exploratory Concepts and Skills for Grades 7-8

Data Analysis, Statistics, and Probability

✓ Make predictions, conduct experiments, and discuss discrepancies to develop understanding of actual vers
✓ us predicted outcomes.

Grades 9–10

Measurement <u>Understand measurable attributes</u> of objects and the units, systems, and processes of measurement <u>Apply appropriate techniques, tools, and formulas</u> to determine measurements

10.M.1 Relate changes in the measurement of one attribute of an object to changes in other attributes, e.g., how changing the radius or height of a cylinder affects its surface area or volume.

Data Analysis, Statistics and Probability

<u>Formulate questions</u> that can be addressed with data and collect, organize, and display relevant data to answer them . <u>Select and use</u> appropriate statistical methods to analyze data . <u>Develop and evaluate</u> inferences and predictions that are based on data

Students engage in problem solving, communicating, reasoning, connecting, and representing as they:

10.D.1 Select, create, and interpret an appropriate graphical representation (e.g., scatterplot, table, stem-and-leaf plots, box-and-whisker plots, circle graph, line graph, and line plot) for a set of data and use appropriate statistics (e.g., mean, median, range, and mode) to communicate information about the data. Use these notions to compare different sets of data.

10.D.3 Describe and explain how the relative sizes of a sample and the population affect the validity of predictions from a set of data.

Grades 11–12

Data Analysis, Statistics and Probability

<u>Formulate questions</u> that can be addressed with data and collect, organize, and display relevant data to answer them <u>Select and use</u> appropriate statistical methods to analyze data <u>Develop and evaluate</u> inferences and predictions that are based on data

12.D.1 Select an appropriate graphical representation for a set of data and use appropriate statistics (e.g., quartile or percentile distribution) to communicate information about the data.

*Please refer to connections to the current draft Mass. Frameworks (2013) on our website at:
http://harvardforest.fas.harvard.edu/sites/harvardforest.fas.harvard.edu/files/NGSS%20Connections%20to%20Harvard%20Forest%20LTER%20Schoolyard%20Ecology%20Projects-10-2014.pdf