Standard 6—Interconnectedness: Common Themes Elementary

Systems Thinking

1. Through systems thinking, people can recognize the commonalities that exist among all systems and how parts of a system interrelate and combine to perform specific functions.

Students:
- **observe and describe interactions among components of simple systems.**
- **identify common things that can be considered to be systems (e.g., a plant population, a subway system, human beings).**

Models

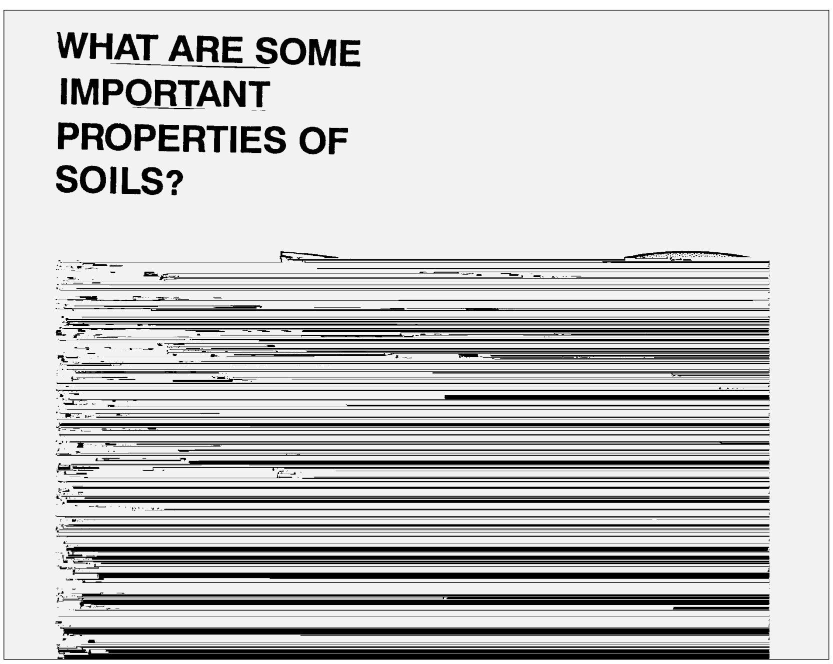
2. Models are simplified representations of objects, structures, or systems used in analysis, explanation, interpretation, or design.

Students:
- **analyze, construct, and operate models in order to discover attributes of the real thing.**
- **discover that a model of something is different from the real thing but can be used to study the real thing.**
- **use different types of models, such as graphs, sketches, diagrams, and maps, to represent various aspects of the real world.**

This is evident, for example, when students:

▲ compare toy cars with real automobiles in terms of size and function.
▲ model structures with building blocks.
▲ design and construct a working model of the human circulatory system to explore how varying pumping pressure might affect blood flow.
▲ describe the limitations of model cars, planes, or houses.
▲ use model vehicles or structures to illustrate how the real object functions.
▲ use a road map to determine distances between towns and cities.

Sample Problem/Activity



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

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Standard 6—Interconnectedness: Common Themes Elementary

Patterns of Change

Optimization

5. Identifying patterns of change is necessary for making predictions about future behavior and conditions.

Students:

- **use simple instruments to measure such quantities as distance, size, and weight and look for patterns in the data.**
- **analyze data by making tables and graphs and looking for patterns of change.**

This is evident, for example, when students:

- ▲ compare shoe size with the height of people to determine if there is a trend.
- ▲ collect data on the speed of balls rolling down ramps of different slopes and determine the relationship between speed and steepness of the ramp.
- ▲ take data they have collected and generate tables and graphs to begin the search for patterns of change. **and**
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Students will understand the relationships and common themes that connect mathematics, science, and technology and apply the themes to these and other areas of learning.

Magnitude and Scale

3. The grouping of magnitudes of size, time, frequency, and pressures or other units of measurement into a series of relative order provides a useful way to deal with the immense range and the changes in scale that affect the behavior and design of systems.

Students:

- **cite examples of how different aspects of natural and designed systems change at different rates with changes in scale.**

Equilibrium and Stability

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Standard 6—Interconnectedness: Common Themes Commencement

Systems Thinking

1. Through systems thinking, people can recognize the commonalities that exist among all systems and how parts of a system interrelate and combine to perform specific functions.

Students:
- **explain how positive feedback and negative feedback have opposite effects on system outputs.**
- **use an input-process-output-feedback diagram to model and compare the behavior of natural and engineered systems.**
- **define boundary conditions when doing systems analysis to determine what influences a system and how it behaves.**

This is evident, for example, when students:

▲ describe how negative feedback is used to control loudness automatically in a stereo system and how positive feedback from loudspeaker to microphone results in louder and louder squeals.

Models

2. Models are simplified representations of objects, structures, or systems used in analysis, explanation, interpretation, or design.

Students:
- **revise a model to create a more complete or improved representation of the system.**
- **collect information about the behavior of a system and use modeling tools to represent the operation of the system.**
- **find and use mathematical models that behave in the same manner as the processes under investigation.**
- **compare predictions to actual observations using test models.**

This is evident, for example, when students:

▲ add new parameters to an existing spreadsheet model.
▲ incorporate new design features in a CAD drawing.
▲ use computer simulation software to create a model of a system under stress, such as a city or an ecosystem.
▲ design and construct a prototype to test the performance of a temperature control system.
▲ use mathematical models for scientific laws, such as Hooke's Law or Newton's Laws, and relate them to the function of technological systems, such as an automotive suspension system.
▲ use sinusoidal functions to study systems that exhibit periodic behavior.
▲ compare actual populations of animals to the numbers predicted by predator/ prey computer simulations.

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Standard 6—Interconnectedness: Common Themes Commencement

Patterns of Change

5. Identifying patterns of change is necessary for making predictions about future behavior and conditions.

Students:

- **use sophisticated mathematical models, such as graphs and equations of various algebraic or trigonometric functions.**
- **search for multiple trends when analyzing data for patterns, and identify data that do not fit the trends.**

This is evident, for example, when students:

▲ use a sine pattern to model the property of a sound or electromagnetic wave.

▲ use graphs or equations to model exponential growth of money or populations.

▲ explore historical data to determine whether the growth of a parameter is linear or exponential or both.

Optimization

6. In order to arrive at the best solution that meets criteria within constraints, it is often necessary to make trade-offs.

Students:

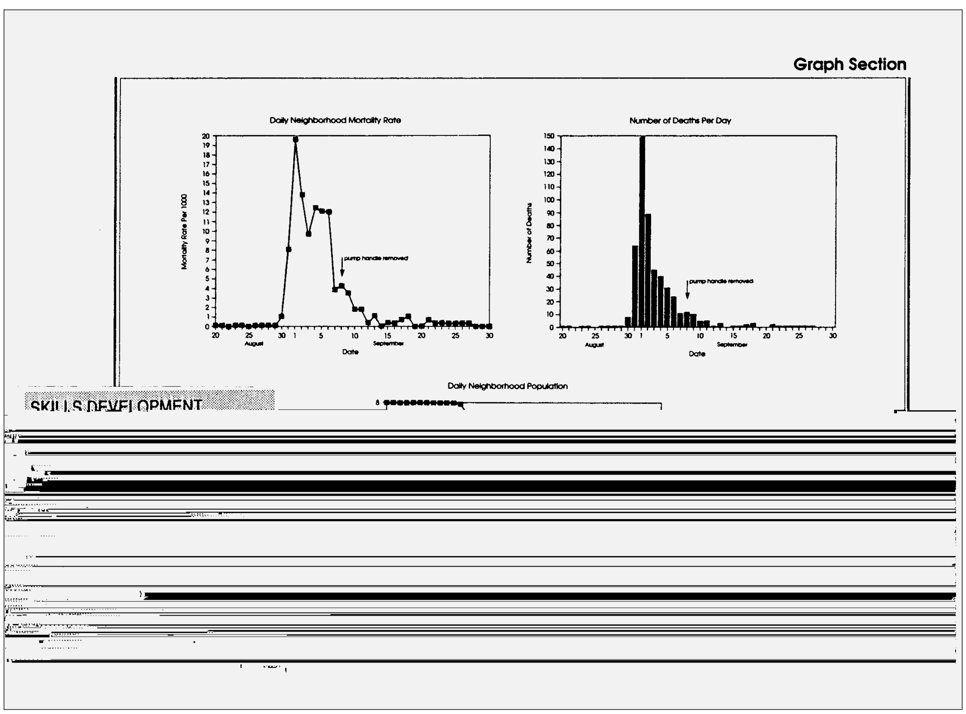
- **use optimization techniques, such as linear programming, to determine optimum solutions to problems that can be solved using quantitative methods.**
- **analyze subjective decision making problems to explain the trade-offs that can be made to arrive at the best solution.**

This is evident, for example, when students:

▲ use linear programming to figure the optimum diet for farm animals.

▲ evaluate alternative proposals for providing people with more access to mass transportation systems.

Sample Problem/Activity



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