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Mathematics and Ecology: Through the Window Garden

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Introduction

In the era of an increasing demand for mathematics to be made relevant to the other subject areas, and to events that directly affect the lives of the learner; there is much difficulty to find curriculum materials, text books and other teaching aids that will enable the classroom teacher to effectively bridge this gap.

This unit will attempt to provide a linkage between the subject of ecology and the mathematics in the classroom.

This unit will also try to incorporate the new direction for teaching mathematics. These ideas as set out in the Professional Standards for teaching mathematics and include the following responsibilities for teachers.

1. The creation of an environment that fosters learning.

2. To create worthwhile mathematical tasks.

3. To provide the tools for enhancing discourses.

These responsibilities for mathematics teachers require that the teacher provide an atmosphere in which the student can develop mathematical proficiency, and in which the student is constantly encouraged and to work both independently or collaboratively as members of a learning team.

If the gap is bridged between ideas from ecology and mathematics, then teachers can pose tasks that will engage the students' intellect and thus foster a better understanding for the concepts and procedures, and will therefore stimulate the students and to make the necessary connections between mathematics and science.

Since it is the teacher's responsibility to enhance discourse, if the teacher cannot find all the materials to encourage this discourse; then these materials will have to be developed by the teacher.

The rationale and General Objectives for the Unit

There have been much talk in the media about humans and their relationship to the environment, and many students often wonder what is, and will be their contribution to maintaining the environment that is safe from pollution, and therefore fit for continued existence. The theme behind the development of this unit will be to present topics that are presently found in the mathematics curriculum and use them to create a link between ecology and mathematics.

It has been a difficult task to find hands on projects that will capture the imagination of the student and at the same time teach important mathematics concepts.

This unit will attempt to provide hands-on activities through the creation of a classroom window garden. Students will plant, build where necessary containers, develop glass ecology systems; and during these procedures apply the concepts of area, volume, perimeter, weights and weight conversion and simple graph to investigate and relate the activities of plant growth to mathematics.

I share the beliefs that if teaching is to be relevant to the students needs then students must become involved in the learning /teaching process, therefore this unit will require the students to undertake simple projects, and be engaged in some type of activity.

General Objectives of the Unit

The unit will be designed to:

(a) provide teachers some hands-on activities to experiment with their mathematics class
(b) find some link between the topics in ecology and mathematics
(c) develop the students ability to apply their knowledge in mathematics to the task of problem solving.

The format of this unit will take the form of a series of mini lessons, complete with activities and projects for the students. The unit will consider as its audience the student in both middle and high schools.

Overview of the topic

What is ecology?

Ecology is the study of the relationship of organism to their environment and of organisms to one another. It incorporates elements from all levels of biological science from molecular, cellular, genetic and physiological levels of species, communities and the whole world.

Ecosystems:

An ecosystem is an ecological unit; it can be a subdivision of the landscape, a geographic area that is homogeneous, and very different from neighboring areas. Therefore this term can be applied to a meadow, a forest, a lake, a pond, or any unit of the landscape with a boundary.

Ecosystems are made up of three components: organisms, environmental factors, and ecological processes. In other words it comprises organisms, species, populations and communities, soil, climate and other physical factors and processes such as energy flow, nutrient cycling, water flow, freezing and thawing.

Organisms are important units of ecology. Over time the organisms have evolved in harmony with their environment, and as a result many internal controls keep them in dynamic equilibrium with their world around them. Some organisms, for example plants remain fixed to their environment and must be able to survive whatever climatic variations occur, on the other hand some small animals can move about to escape some of the harsh realities of their environments.

Food Chains and Food Webs

Life is maintained by organisms particularly plants that use sunlight to convert carbon dioxide and water into energy for all life. This process of fixing carbon dioxide by green plants is called photosynthesis. There are purple bacteria that assimilate carbon dioxide by using hydrogen sulfide (H2S) instead of water (H2O) as the reducing agent. Some other bacteria use organic compounds for reducing carbon dioxide. Green plants and various bacteria are known as the producers in an ecosystem.

Higher plants and green algae perform most of the carbon fixation in the world, and chemosynthetic bacteria are of more significance on moving certain materials such as sulfur, through the sediments for ecosystem.

The producers fix their own food supply and are called Autotrophs (self-feeding); on the other hand Heterotrophs depends upon on other organisms for food. Organisms that feed on other organisms are called consumers. Those that feed on plants are called Primary consumers or Herbivores. Carnivores that feed only on those animals that are secondary consumers is a tertiary consumers.

If there were only producers and consumers the system would not work very well, because the flow of materials would be in only one direction. That is it would be from lower to higher order organism. There needs to be the medium that return these compound to move elemental forms so that they can cycle and be used over and over again in the food chain. This process of recycling requires a group of organisms known as *Decomposers* . Bacteria and fungi play the role of decomposers. Bacteria act on animal tissue and fungi on plant tissue. In this process plant and animal material is degraded enzymatically and released as basic elements into the environment, where the elements are again available to the producers for reuse.

Energy on the other hand is not recycled. It moves undirectionally through an ecosystem, being consumed at each step of the food chain.

Food Chains: An example

A field rat derives its energy by eating grass, then the rat is consumed by weasels, which is then eaten by hawks and owls.

In the aquatic food chain, the phytoplankton, the primary producers are eaten by zooplankton, these are in turn eaten by fish which is then eaten by porpoises, these porpoises are then eaten by killer whales.

Sometimes these animals may escape their predators and die of old age. These dead animals are colonized by blowflies that lay their eggs in the carcasses that are eaten by carrion beetles, and are consumed by bacteria. Food chains does not exist in isolation but interact to form food webs.

Food Webs:

The food web is the network within an ecosystem through which energy flows to the entire community of plant and animals. Most food webs have a great deal of stability. They will react when disturbed unless the disturbance is too extreme. If the disturbance is too great the species are wiped out or the entire breeding populations are destroyed then recovery to its previous forms may never occur.

Examples of decimation of ecosystems:

(a) In areas of human activity the natural ecosystems have been replaced by urban ecosystems.
(b) Most of modern Europe has had its original natural ecosystems replaced by cultivated or managed ecosystems.
(c) The Great Lakes fisheries have been damaged by human activities beyond the recovery to their original form.

Response to Physical Factors

All organisms display a diversity of responses to the physical factors of their environments. Some organisms are highly sensitive to certain physical factors, and the range of conditions they can tolerate is severely limited. Other organisms have broad ranges of tolerance and are much less sensitive to environmental factors. Organisms must have a suitable amount of heat, light, water, nutrients and other factors in order to carry on growth and reproduction. This balance must be maintained too much of some factors may be just as bad as too little.

Each stage in the life cycle of an organism has a limiting factor response, some stages are much more sensitive than others. The tolerance ranges of the young is much narrower that those of adults; seeds, eggs, embryos, larvae, and seedlings are much are therefore more sensitive to environmental factors than mature plant and animals.

The Law of Limiting Factors

The law of limiting factors states that the population size of any particular species may be limited by one or more factors that are present in inadequate or over abundant amounts. The law of limiting factors was first demonstrated from one simple ecosystem such as crop. Natural ecosystems have so many interacting organisms and many interconnections among them that a simple cause and effect relationships between them is often difficult to demonstrate. Sixteen different chemical elements have been identified as essential for the survival of most species. These are carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, boron, molybdenum, copper, zinc, and chlorine. There are several other elements that are required in trace amounts by some species; these elements are sodium, vanadium, cobalt, iodine, selenium, silicon, fluorine and barium. Some elements seem to be consistently low or consistently high in many ecosystems. If soils are low in phosphorus then the growth of plants will be limited; and if an essential element is present in too high a concentration then this could be toxic to a particular organism; example too much boron in a soil will be toxic to many plants and animals.

The conditions under which an organism lives may determine its requirements for a particular element. For example plants in a sunny climate may require a substantial amount of zinc, whereas the same plant growing in the shade may need very little zinc.

The question of limiting factors, the law of tolerance is extremely complex because nothing acts alone in nature. Many plants and animals responses to a given element of environmental factors are *synergistic* , in that the response to one element of factor depends on the amounts of all the others, for example if nitrogen is limiting to grasses, their resistance to drought diminishes.

These are some of the factors that must be considered when ecosystems respond to human intrusion.

(a) An organism may have a wide range of tolerance to some factors and not to others.
(b) Organisms that are most tolerant are likely to be most adaptable to a range of habitats.
(c) An organism’s tolerance to a given factor may change with the availability of other factors.
(d) Organisms in nature may not always be growing under optimum conditions.
(e) During the juvenile or reproductive stages of the life cycle, an organism is least tolerant and therefore most susceptible to limiting factors.

Temperature Response

All organisms are sensitive to temperature, and have distinct temperature preferences. Some organisms have broad temperature tolerances while some have narrow temperature responses. The following are the ranges of body temperatures for various organisms.

The Antarctic fish Trematomus benacchi has a body temperature tolerance range of 4 degrees (from -2° to 2° C). The desert pupfish tolerates temperatures from 10° to 4° C, with a preference for temperatures about 20° C. Most cold blooded animals have low metabolic rates and body temperature of the air or water in which they are immersed. Reptiles on the other hand may have body temperatures that are regulated to remain within narrow limits except for some animals that hibernate, then they go into a cold blooded state. The normal body temperature for a human is about 37° C, but can survive with body temperature going as low as 22° and high as 43° C. Birds have the highest body temperature which ranges between 41° and 44° C.

Plants generally have temperatures close to air temperature except in strong sunlight, when the leaves may be 10° to 20° C above the air temperature, and under cold clear skies at night they can have temperatures of of 5° to 8° C below the air temperature. All plants and all blooded organisms have a behavioral and growth response that increases with increasing temperatures above some low temperature tolerance limit, the behavioral and growth response reaches a maximum at some optimum temperature and decreases sharply at higher temperatures until the thermal maximum is reached.

Many plants begin to sustain thermal damage when their tissue temperature exceeds 43 degrees Celsius. Some plants that adapt to high-temperature habitats have good resistance to thermal damage at the temperature likely to be encountered, thus they may have relatively poor cold resistance to low temperatures.

Algae usually optimize their photosynthesis and growth response to the temperature of the stream of lake which they are living, but because of temperature changes throughout a yearly cycle many bodies of water have organisms with different temperature levels.

Light response

Photosynthesis is a photochemical process that requires light to convert carbon dioxide and water to carbohydrates, starch and sugars. Most plants respond to increasing light intensity with increasing photosynthetic rates. Some plants require the shade to grow well and must avoid exposure to sunlight. These shade loving plants respond to photosynthesis with more sensitivity to low levels of solar irradiance than do sun loving plants but the sun plant has a greater photosynthetic rate in full sunlight than does the shade plant.

Aquatic plants respond to light in the same way as that of land plants.

Animals respond to light in a number of different ways. Some organisms have a biological clock, which is a physiological mechanism for determining time. Some of these biological clocks seem to be regulated by external factors. Some plants and animals possess responses having about a 24 hour periodicity. These are called circadian raythorns. These timing mechanisms regulate endocrine changes, gonadal development, color changes in birds in spring and autumn mating behavior in moths, insect feeding, flowering and many other responses. Light intensity and day length clearly are important in these cases. If environmental changes occur it may have a direct impact on the biological clock of many plants and animals.

The Carbon Dioxide Response

Plants assimilate carbon dioxide during the process of photosynthesis; producing carbohydrates and other compounds. The photosynthetic rate of all plants increase with the concentration of carbon dioxide in a linear manner at normal atmospheric concentration.

The Carbon Cycle

The only source of carbon to produce organisms is the atmospheric carbon dioxide which is transformed from its gaseous state into carbohydrates and other organic materials by photosynthesis. Respiration of carbon dioxide by all organisms returns carbon to the atmosphere. Forest and grass fires also release carbon dioxide to the atmosphere. Carbon is deposited in soils and sequestered in sediments of streams, lakes, and oceans. Although the carbon cycle is simple the carbon exchanges through the food chain and the ocean surface waters are complex.

Prior to human intervention, the carbon flows in and out of the atmosphere may have been in equilibrium.

(figure available in print form)

The Properties of Water

Water is essential to all life and is about 70 percent of the weight of most plants and animals. The unique physical properties of water enables it to play a dynamic role in shaping the landscape and creating special habitats for all organisms. Water can be found in three physical states, as liquid, solid, and gas. It is colorless, odorless, transparent to visible light, and opaque to infrared radiation.

Water vapor in the atmosphere allows sunlight to pass through to the earth's surface, where the sunlight heats the ground, evaporates water, or is used in photosynthesis. Water has low viscosity and flows easily. Water has its greatest density at 4 degrees Celsius. Therefore lake freeze at the surface and have water temperature at the bottom of 4 degrees Celsius. Water expands upon freezing, some ice is less dense than water it floats.

Many organisms can survive the winter in the liquid cold water of deep lakes where no freezing takes place. Water evaporates readily into the vapor state and consumes heat in the process. Water vapor is less dense than air therefore moist air is less dense and more buoyant that dry air. Moist air rise in the atmosphere until it is cooled to the condensation temperature at which level clouds are formed.

Plants absorb water through their roots, on the other hand solar heating of the leaves removes water by causing release of water vapor into the atmosphere, this process is called *Transpiration* . Through the process of *Osmosis* the water flows from roots to leaves and transports from the soil all the vital nutrients needed by the plant for growth. The water in the leaves is necessary for photosynthesis and growth. A lack of water inhibits plant growth and adequate water supply promotes growth on the other hand too much water can be a limiting factor to those plants that adapt to using lesser amounts. Some plants have adapted to growing in water.

The Hydrological Cycle

Water is evaporated by the sun from lakes, ponds, soils and vegetation, it rises into the sky where it condenses and falls back as rain, snow, or dew then becomes available to the biosphere.

Over the world the evaporation and precipitation of water is in balance, although evaporation exceeds precipitation over the oceans and the opposite over the land. Only about 5 percent of the earth's total water is in circulation through the hydrosphere and 95 percent is bound up in the lithosphere (the region if the earth composed of rocks). It takes a water molecule about ten days to be transported through the atmosphere before precipitation takes place.

Plants and animals respond to a combination of water, temperature, and light. The high temperatures and sunlight there is higher transpiration rates from plants, and high evaporation rates from the soil, lakes and oceans. The rate of water loss from any surface depends in particular on the energy exchange with at surface by radiation and convection.

The community of plants and animals present in the ecosystem depends on the availability of water.

The continuing modification by humans of the global hydrological cycle can have serious consequences on climate, and therefore will affect life as we know it.

(figure available in print form)

Population and Communities

Ecosystem has a large number of individual organisms which belong to many different species. A population is defined as that assemblage representing the total number of individuals of a single species in a specified area. The member of birch, of maple trees in a forest constitute the population. All the different populations in a forest would be called a community.

The plant or animal community has a population in which the most prevalent species are those that are in abundance, and the very rare and extremely common species are fewer in number. The graph that shows the population distribution in a system is called *lognormal* .

Ecological Succession

Every community of organisms is subjected to a changing and fluctuating environment, and in turn, is itself changing in composition. There are diurnal, monthly, and annual cycles, long term trends and short term disturbances. The rates of flow of energy, nutrients, and water change. Plants and animals die and are replaced by new generations. A community of organisms can appear relatively stable while at the same time containing a mosaic of patchiness caused by fires, blow-downs, floods, or other disturbing events. The long term constancy and recovery of a community structure is an indication of its relative stability.

When a community of plants and animals is severely disturbed by fire, insect infestation or lumbering, these will occur great changes in the composition of the community and ecological succession will result. Ecological succession is an orderly process of community development that involves changes in species structure and community processes with time an ends in a stabilized ecosystem. For example, a virgin forest may be cut down for lumbering, or destroyed by fire, it then becomes an open field of grasses and herbs, followed by shrubs and young trees of certain species, followed by other tree species. After hundreds of years the mature forest may once again occupy the site.

At each stage of this preceding succession, the micro-climate of the site was modified by the plants themselves. At first it was an open exposed sunlit site, the soil was warm and dry, as grasses and fern covered the surface the soil became cooler and more protected against moisture loss. After the establishment of trees, the soil was even more shaded, cooler and more moisture retentive. The wind blowing over the site, was a completely different during each stage of the succession, the ecosystem had a different character during each progressive succession.

Succession does not always lead to climax communities nor is succession only limited to plants. It occurs among all organisms, plants and animals.

It is important to realize the dynamics that occur within ecosystems and the patchiness of communities. There is always disturbance in nature, fire, wind, thaw, drought, flood, earthquake and the result is a certain pervasive patchiness to any community. Whenever there is disturbance by humans there will be opportunity for succession.

Global Change

Global change is the significant interactions of biological, chemical, and physical processes that pertains to changes in the earth system and that are most susceptible to human perturbation.

Global change takes place in air, water, soil and living organisms through a set of linkages. These linkages begin with incoming solar radiation and the earth atmosphere. The climate produced by this interaction affects all living things. The climate is also affected by those living things, by the land mass and water bodies of the earth, and by geologic activity.

The following links exist between climate and vegetation.

> *Atmosphere* : affects plant survival and growth through carbon dioxide and pollutants: plants affect atmosphere by storing carbon and producing oxygen.
> *Temperature* : determines plant survival, growth and geographic distribution; affects productivity, governs evaporation and transpiration; it is affected by plant biomass and reflectance properties of foliage.
> *Water* : rainfall influences plant survival and growth, affects the regional water balance through evaporation and transpiration.
> *Soil* : Stores water and controls plant-water relations, stores carbon, nitrogen and other chemicals. Also, it cycles nutrients through plants, releases chemical through the action of

decomposers, and is eroded by surface runoff from rainfall.

Research has pointed to massive human impacts on land, water and the atmosphere. As economic development accelerated in all countries, population increased in poorer countries, stable ecologies such as tropical forests and the ocean were significantly degraded.

As larger economies and populations burned more fossil fuels and used more chemicals, this led to greater accumulations in the atmosphere of greenhouse gases - carbon dioxide (CO2), nitrogen, sulfur and chloro-floro carbons. These higher build up of gases have led to changes in the global environment. Scientists have mathematical models to show warming trends 50 to 100 times greater than changes since the last glaciation.

There are the four observable global-scale changes that are evident; accumulating greenhouse gases, diminished ozone layer; rising sea levels, and acid deposition. The greenhouse effect is produced when some of the infrared radiation is absorbed by carbon dioxide and re-radiated back to earth rather than being transmitted into space.

Climate Effects

The most concern about the atmospheric carbon dioxide is focussed on climate change. The computer model used to produce warming trends suggest that a doubling of atmospheric carbon dioxide would increase global average temperature from 1.05° to 4.5° Celsius. with high latitude temperatures rising as much as 9° Celsius; with most of the warming taking place in the winter.

Indirect Effects

With the induced changes in the climate frequency of extremes could significantly reduced global agricultural production; induce changes in the hydrologic cycle; thus affecting forests, wildlife, fish populations and other endangered species. The increased carbon dioxide concentrations in the atmosphere increase the amounts and the rate at which carbon dioxide is fixed in plants.

The existence of carbon dioxide and vegetation link would result in greater annual turnover of organic carbon, because decomposer organisms are provided with more litter and warmer temperatures in which to metabolize the litter.

The Greenhouse Effect

A greenhouse stays warm because sunlight can come in through the transparent glass, but long wave (infrared) radiation cannot be transmitted out because the glass is opaque to infrared radiation. The radiation trapped inside warms the interior surfaces of ground plants and other materials. A greenhouse is also effective because it does not let convection (air movement) remove heat to the external environment except through controlled vents.

(figure available in print form)

In the atmosphere, certain gases (carbon dioxide and water vapor) act like the glass of the greenhouse. Sunlight is allowed to pass through the earth’s surface, where it is absorbed, but they interfere with the passing of long wave radiation outward. This process is known as the greenhouse effect, it balances the incoming and outgoing radiation at a level that warms the earth’s surface.

The earth’s surface and atmosphere maintain a balance between the incoming flux of solar radiation and the outgoing infrared radiation. As a result of the radiation balance the mean surface temperature of the earth is about 15 degrees Celsius. If this balance is disturbed then the temperature may go up or down. Increased cloud cover can reflect sunlight to space, reduce the amount of sunlight reaching the ground and cause cooling. Increasing amounts of carbon dioxide and water vapor can cause warming of the global climate.

Climatologists study these changes, by using computer models, it is found that by doubling the amount of carbon dioxide concentration in the atmosphere, there can be an increase in the global mean temperature of the earth of about 3 degrees Celsius +/- 10 degrees Celsius. This much increase in the mean surface temperature is very significant and is in fact greater than any naturally occurring changes in temperature during the past 10,000 years.

Evidence has shown that the concentration of carbon dioxide in the atmosphere and the resulting greenhouse effect is caused by human activities, such as the burning of fossil fuels, and the cutting of forests (deforestation).

If this warming trend continues then there could be serious consequences. Glaciers may melt, sea levels may rise, agricultural production may be affected, and the ecosystem may undergo substantial changes.

Readings in Ecology to learn Mathematics, New Connections, Questions and Challenges, Using the Window Planter to Provide Hands-on Activities.

Given the recent considerations about pollution concerns for the environment, the effects of global warming, and the role that human activities play in this, there is need to change the school curriculum to reflect these developments.

The role of writing and reading in the mathematics curriculum must be considered. This unit will attempt to incorporate readings from the topic of ecology, and articles that deal with the current concerns of global warming, waste management and any other discussions that may be relevant in the math class.

From these readings, students will be shown the interconnections between science and mathematics, and that in many cases mathematical concepts are necessary to understand ecological concerns.

By planting a window garden and experimenting with bottle biology, students will not only be taught mathematics, but will be forced to consider that planting a seed and maintaining growing things in their environment not only help to beautify the space, but contribute to the global cycles that maintain the global balance.

Lesson Plan I

Topic: What is Ecology?

Introductory Statement:
Student will discover some of the ideas and concepts that make up the topic of Ecology

Materials:
Copies of sections of this paper or Copies of any other relevant writings, journal articles that concerns ecology (global warming, pollution).

Key Questions:

1. How does human behavior affect the environment?
2. How does a system replenish itself? What can people do to aid this process?

Background Information
1. Discussion on the temperatures of the past winter, the summer rainfall.

2. Discussion on the recent Environmental Conference in Brazil.

3. Discussion of news items that talked about the rate of global warming.

4. Introduction of the topic of Ecology or Environmental Studies and what it teaches.

Management Suggestions:

I. Divide the class into small groups of 4-5 students. This is the home group.
II. Students with the same number will form a different group. This will be called the expert group.
III. Each expert group will be given a different section of the article (e.g. what is ecology, food web, etc. The article will be broken down in various sections) The expert groups will be required to read and discuss their section, then return and teach this section to their home group).
IV. Select articles that are long enough with sufficient ideas, that will keep the class involved for at least half the period.
V. The expert group could meet for an entire period if the time is required.

Procedure:

1. While the expert group reads and discusses, the teacher's responsibility is to maintain each group on task.
2. Have students return to their home group and each expert will in turn inform the entire group of the information gathered from their reading.
3. Design simple test questions, or discussion on each of the various topics.

Discussion questions. (Research Questions)

1. What are the areas that are covered by Ecology?
2. What is an EcoSystem?
3. Discuss the role of each group of living things.

Extended Activities

1. Discuss the evidences that have shown that the Earth's climate has changed through natural procedures in the past?
2. Brainstorm, Evidences that probably, the earth's climate in your region has changed over the past years.
3. What is Global Warming; What effect will it have on our climate?
4. Why is it possible to compare the Earth's atmosphere with that of a greenhouse?
5. How can this information affect or change the way I think and live with respect to the earth's atmosphere. What changes can I make:
   (a) at school?
   (b) at home?
   (c) In any other aspect of life?

Curriculum Coordinates

Language Arts:
Write a story about any ecological system (a pond, a fish tank, a flower garden, a grassland region)

Art:
Draw a picture to show succession in any ecological area of your choice.

Lesson Plan II

Topic Area: Reading, constructing and interpreting graphs.

Introductory Statement
Students will be able to read and interpret graphs will be able to assimilate the information that is displayed.

Math Skill:
1. Using data

2. Computation

3. Graphing

4. Using scales

Readings
Deforestation is rapidly progressing in the Amazonian Areas of active development such as in Rondonian and Brazilia. Western Amazonia is associated with the highest deforestation rates. Other Amazonian countries, such as Peru, Colombia, Venezuela and Bolivia also have high rates of deforestation. It is expected that future deforestation rates will be higher because of development policies of the Amazonian countries. If deforestation were to continue at this rate, most of the Amazonian tropical forests would disappear in less than 100 years. One question that arises is whether the large scale of deforestation in Amazonian might affect the regional climate with consequent implications for the biota in the region.

(from: Amazonian Deforestation & Regional Climate Change. Journal of Climate Oct. 1991.)

Materials
1. Copy of reading material

2. Picture of the region for discussion

3. Data with record of rainfall

4. Graph paper, ruler

Key Questions:
1. How does deforestation in a region affect the climate?

2. Does deforestation impact the build up of CO_2 in the atmosphere?

Math skill: Drawing a graph

Background Information:

Evidence has shown that continued deforestation in the rain forest region has contributed to the global warming. Forests have been cleared for economic reasons by the countries involved (ex. for agriculture, cattle rearing). This has caused many changes in the lives of the original inhabitants of the region.

Management Suggestions:

1. Divide class into small groups (4-5 students).
2. Provide each group with a copy of the reading.
3. Provide various (different) questions for each group to answer (a small write up to be presented by each group).
4. Select pictures, graphs and data on the rainfall of the region.
5. This lesson may be taught over two class periods.

Procedure:

1. Divide the class into groups and distribute material.
2. Review the effects of deforestation and meaning of deforestation from previous reading.
3. Have groups read and discuss the material.
4. Re-assemble the class and discuss each group’s responses. List main ideas on chalkboard. (Have an individual from the group make the presentation).
5. Present pictures of past and present forests, (before and after deforestation). Discuss.
6. Provide the data on rainfall of a region for the past year (any available rainfall data or graph will do). Discuss the graphs.
7. Give students data for rainfall and have them construct the graph.
8. Draw conclusions based on the data.

Discussion Questions:

1. Is there evidence that the forests will re-establish themselves? (consider climate change and rainfall levels.)
2. Discuss the arguments pro and con of deforestation.
3. How will deforestation in the Amazon region affect the temperatures and climate of your region.

Curriculum Coordinates:

Geography:
Locate the Amazonian countries on a map. Discuss the main products, for export of these countries.

Current Events:
What were the outcomes of the last Environmental Conference.

Mathematics:
Keep record of temperature changes and graph the result.

Lesson Plan III

Topic Area: Percentages. Interpreting and calculating percentages.

Readings Before the industrial and agricultural revolutions, humans may have had relatively little impact on the global cycling of Carbon. But with increased industrialization and agricultural development, human activities play a more significant role in some of the natural cycles. For example, the current amount of CO_2 injected into the atmosphere annually from fossil fuel combustion is equivalent to 2.5% of the combined amount exchanged between the atmosphere and the oceans.

Introducing Statement

Students will discover the rate of increase of Carbon dioxide in the atmosphere and the results on the ecosystems.

Materials Printed copies of the reading for each group.

Math Skills
1. Data Gathering.

2. Trends and Forecast.

3. Interpreting percentages.

4. Finding the percentage increase.

5. Computation.

Management Suggestion:
1. Students will be working in small groups reading the information.

2. Select data on the Carbon increase on different periods. (Graph data)

Procedure:

1. Keep the original groups of 3 or 4.
2. Give students the desired time to read the information.
3. Provide questions for each group to respond to Carbon emission in the atmosphere.
4. Have each group select a representative to discuss the response.
5. Review percentage (using the 2.5% in the reading to make up examples).
6. Discuss the carbon cycles, (The sources of Carbon in the atmosphere.)

Problems for Discussions:
The Carbon reservoirs of the world are immense, approximately 32,00 Gt of Carbon are in the ocean sediments, 12,000 Gt in fossil fuel reservoirs, and 1750 Gt in terrestrial plants and animals.

(a) What is the total amount of carbon in reserves?
(b) If there is an increase of 2.5% due to the burning of fuel, how many Gt would this be per year?
(c) Current measurements have indicated a 0.4% annual increase of carbon dioxide in the atmosphere if the atmosphere in 1982 contained about 721 Gt how much carbon can be found in the atmosphere today?

Curriculum Coordinates Science Research the latest findings in the increase in carbon dioxide in the atmosphere.

Language Arts
Write letters to the Government agencies explaining concerns about the increase emission of carbon dioxide in the atmosphere.

Geography

(a) Draw a map of the world locating the areas that produce the largest quantity of fossil fuel. Also locate the countries that use most of the fuel produced.
(b) Develop a list of alternate sources of energy to fossil fuel. Discuss safety concerns.

Lesson Plan IV

Topic: Interpreting numbers written in Scientific notation in the literature.

Introductory Statement
Students will be able to observe the application of scientific notation.

Math Skills
Interpreting Scientific notation; Writing numbers expressed scientific notation on standard form.

Readings
The present atmosphere total of 720 x 10^{15} gt (342 ppm) of elemental carbon represents a significant increase from about 590 x 10^{15} gt, largely due to the accelerated burning of fossil fuels for energy.

Background Information:
Measurements of atmospheric CO2 levels are taken at the observatory at Mauna Lou, and other locations on the globe. The figures obtained indicate that CO2 emissions in the atmosphere has increased steadily over the years. Scientific notation, the method of writing very large numbers more compact has been used to record these readings.

Procedure

1. Review the place value chart. Provide examples so that students can identify the value of each digit in the given number.
2. Review Scientific notation (numbers can be expressed in the form a x 10^{n})
3. Give examples of changing from standard form to scientific notation and from scientific notation to standard form.
4. Provide the reading for small group discussion.
5. Provide follow up questions based on the reading that will require the manipulation of scientific notation.
6. Return to the large group and let the representatives of each group discuss their reports with the class.

Discussion Questions

(a) What is the amount of increase in carbon dioxide in the atmosphere?
(b) Discuss the reason given for these increases.
(c) How can your daily activities help to lower the increase of carbon dioxide in the atmosphere?
(d) Make a list of suggestions for changes:
  i. You can make.
  ii. Governments can make.
  iii. Your community can make.

Curriculum Coordinates:

Language Arts:
Write letters to public officials with voicing concerns about the rate of CO_2 emissions.

Geography:
Locate the place of observation for measuring CO_2. Research the regions of the globe where increases in CO_2 are more apparent.

Locate the large mining centers of the world: areas that have an abundance of limestone rocks.

Mathematics and the Window Garden:
These next few units will consist of a series of mini-lessons that are designed for lower grades and middle school.

Lesson Plan V

Shapes of flower pots.

Task Analysis:

1. To identify the different shapes of flower planter. (Square, octagonal, rectangular prisms, circular.)
2. To recognize the names of the faces.
3. To recognize the corners, line segments, angles.)

4. Identify and draw parallel lines, skew lines, perpendicular lines, diagonals and horizontal lines.

Materials
Have available, different kinds of flower planters. (Children and parents could contribute pots for the class project.) Tape measure.

Organization:
Cooperative group activities. Groups of 4-6; whole class activity.

Procedure

1. Present the pots to students.
2. Have them discuss the shapes in their group.
3. Have students identify the type of shape pots they have in their group: Then list the number of faces, edges, vertices seen.

Extension
Complete a chart with the names of each solid and their number of angles, faces, and vertices.

Lesson Plan VI

Finding the Pattern That Matches

Question:
What if we had to make our own flower pots? (planters)

Task Analysis:
1. Match patterns (Geometric solids) to the real objects.

2. Identify line segments, folds, and vertices.

3. Tell the differences between carved surfaces and flat surfaces.

Materials
1. Geometric nets of solids.

2. Shoe boxes or milk cartons, cylindrical boxes that can be opened up.

3. Scissors, construction paper, rulers, pencils.

Organization: Whole class and group activities.

Procedure

1. Review the vocabulary, points, line segments, vertices and faces with the whole class.
2. Point out these on the boxes.
3. Have students point out boxes that have *similar* shape to the planters.
4. Open the boxes to show how the faces are organized to form the box. (Use words such as top, bottom, sides to identify the faces.)
5. In groups with the *nets* , have students identify the nets or patterns that could be used to make each container.

Extension
Students could draw their own patterns and make solids for the display board.

Lesson Plan VII

How much bigger? (Middle School)

Task Analysis:

1. To find the total surface area of each planter.
2. To use a tape measure.
3. To decide on the necessary data needed to find area.

Materials:
Planters, boxes, tape measure. (Graph paper)

Organization: Whole class and group activity.

Procedure

1. Discuss the meaning of area. Show the amount of space the shape takes up on graph paper or on grids on the chalkboard. (Concentrate on either the rectangular shapes, or the circular shapes in each lesson.)
2. Have students brainstorm on ways to determine the area of the shapes from the grid paper.
3. Discuss the difficulties faced using this method.
4. Have them determine the measurements that need to be made to find the area with rectangular vs. circular shapes.
5. Use the formula for area to determine the area of given shapes.
6. In groups, have students measure and then determine the area of each face, then find the total surface area.

Extension:

1. For cylindrical pots, more work must be done finding the circumference, diameter, and the determination of pie.
2. Use the same measurement approach to determine the volume of each container. This should be done as a separate lesson.

Lesson Plan VIII

Gathering data on soils

Topic: Rate of water penetration in soils.

Introductory Statement
Some soils are better for use in a window planter than others. The rate in which water will soak various types of soils is one criterion for soil selection.

Math Skills:
1. Computation.

2. Data Gathering.

3. Graphing.

4. Rank ordering.

5. Drawing conclusions.

Materials

1. Different types of soils (sand, clay, loam).
2. Coffee cans with tops removed and small holes in the bottom (for drainage).
3. Containers with water and flat container to collect drainoff.
4. Measuring up (Metric containers).

Management Suggestions:

1. Groups of 4 or 5 students (small group).
2. Distribute soil samples to each group. (Select soil samples that vary in compaction).
3. Use dry soil samples.

Procedure

1. Discuss the importance that water plays in plant growth including the dangers of too much water.
2. Discuss the soil composition and its impact on the rate at which water will drain through.
3. Distribute the materials to each group.
4. The coffee cans with the different types of soils will be labeled. Each group will pour 100 milliliters of water in each soil type. The runoff will be collected and measured and the efficiency of each soil type compared. They can also make a measurement of how quickly the water drains through the soils types. Student will collect and analyze the date they collected.

Discussion Questions:

1. What soil type will be the best for the plants? Why?
2. What would happen to plant growth if the sand, loam, clay is used?
3. What soil type will provide more uptake of water for the plants?

Extended Activities

Science

1. More work on soil types and soil formation.
2. The importance of root uptake osmosis.

Math

This lesson could be used:

1. To teach liquid measurement changing measurement units.

2. As an introduction to ratio and proportion.

Lesson Plan IX

Using the Blooms

Topic: Using the leaves, petals and stems of various plants to teach *symmetry* and *congruency* .

Task Analysis
1. To fold the leaves to show symmetry.

2. To match and compare petals of flowers to prove congruency.

Materials
1. Petals and leaves of plants.

2. Mirror (if available), scissors, paper, pencils.

Organization

1. Whole class discussion.

2. Individual activity.

Procedure:
The lesson could be done in two days.

1. Discuss the meaning of symmetry or congruency.
2. Using the leaf show the main vein that acts as the line of symmetry. Fold the leaf to show how both sides match.
3. Using certain flowers (with petals arranged in groups) show the center as the axis of symmetry.
4. Have students draw or trace each type of flower, those with line symmetry and point symmetry.
5. Have them determine in how many ways the leaf can fit its outline. Students can make a list of the type of plants and type of symmetry each has.
6. For congruency students can match leaves to show what types of leaves are congruent.

Extension

1. Students can study different leaf formation of various trees and could look for patterns e.g. Fibonacci sequence.
2. *Science* : Students could take the nature wall to look for different types of leaves.
3. *Art* : Use leaf tracing for decoration. Dry leaves and flowers to make wall hangings.

Conclusion

This Unit has not exhausted all the possible ways that ecology can be integrated into the classroom, but this first attempt has give some ideas as to how this integration could be achieved.

The following are a list of books, articles, and papers that may be useful in providing materials to try this Unit:

Bibliography

Branch, Katherine and Miller, Joseph A. (1992) “Global Change, A Bibliographic Essay on Scientific and related Serials”. Choice 851-860. This article gives a discussion on global change and current investigations into the increase rates of carbon dioxide in the atmosphere.

Byhee, Rodger W. (1991) “Planet Earth in Crisis: How should Science Educators Respond?” American Biology Teacher 53, 145-153. This article outlines policies for curriculum change and instruction that will enhance Science teaching.

“Energy Crisis Perils Life”. (1990) Clearing 66,13-14. Discussed the idea that the use of fossil fuels could render earth uninhabitable long before supplies of them are exhausted. Possible solutions are described.

Gates, David M.(1985) *Energy and Ecology* . Sinaur Associates Inc. Sunderland, Mass. A text on Ecology and Energy.

Huchle, John. (1990) “What We Consume”: The Curriculum Rationale. Geographical Educator 6, 31-36. Explains how to develop students’ critical awareness of environmental problems and how to initiate change.

Monroe, Martha C. (1991) “It’s No Use” Into “Hey, There’s a Lot I Can Do”: A Matrix For Environmental Action Taking. Clearing 67, 32-33. Gives a simple matrix that can be used as a tool for analyzing environmental actions. The matrix focusses on examples of efforts to resolve environmental issues.

Senkevich, V.M. (1991) “Ecological Education Integration of Scientific Knowledge and Figurative Representations”. Soviet Education 33, 47-54. This article describes techniques that integrate knowledge for Science and Art in Ecological studies.

The Green Pages. (1990) Environmental Education Activities K-12. Clearing 66, 26-38. This article presents thirty-eight environmental activities for grades k-12. The topics include seed dispersal, food chains, plant identification, air pollution and recycling temperature changes.

Texley, Juliana. (1991) “The Environmental Impact. Science Teacher 58 (4) 19. Explains the impact of oil spills and oil fires in the Persian Gulf. Provides activities that can be done in the classroom.

United States Department of Energy. (1988) “Atmospheric Carbon Dioxide and the Global Carbon Cycle”.