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The Integration of Science and Math Through Ecosystems

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by Elizabeth I. Kryszpin

My unit, “The Integration of Science and Math Through Ecosystems”, will be taught to students in fifth through eight grade. I teach remedial math to these aforementioned grades and I am at liberty to reinforce their mathematical skills in any way I see fit. I do not teach from a textbook series and I generally garner and glean materials from supplemental sources. Gathering sources appropriate for each grade and conducive to whatever the regular math teachers are teaching in their classes is a difficult task. My students come to class with a general disdain for math and a sense of boredom and frustration towards both me and the extra doses of math I am to spoon feed them. This makes my job even more difficult. Difficulty breeds creativity and resourcefulness. I have learned that my students generally do not like and/or understand math taught and drilled to them in the standard, textbook method. Attempting to repeat this rote method in the past has left both me and the students at odds as well as at our wits’ ends.

The most successful attempts to date have been my integrations of math with other subject areas. The integrations have been fruitful because they have proven to students that math is important and essential to many aspects of their academic as well as day-to-day lives. The integration techniques have taken math out of the vacuum in which my students have experienced and grown to hate it. Teaching in Betsy Ross Arts Magnet School has also fostered the integration of math with other subject areas such as language arts, reading, writing, and social studies because of the interdisciplinary philosophy and nature.

I have not yet attempted to integrate science and math although these two subject areas are probably the most related and dependent upon each other. I ironically have a relatively extensive science background. I haven’t tried the science-math connection yet because I thought that I didn’t have the appropriate equipment to integrate the two areas successfully. I applied to the Institute to expose myself to ideas and concepts about science and more specifically, ecology, which I could easily and subtly integrate into my math-oriented classroom.

GOALS AND OBJECTIVES:

1. To integrate science and math through the study of ecosystems. 2. To increase student awareness of the natural relationship of science and math. 3. To heighten student environmental consciousness by the introduction of ecological theory and concept. 4. To foster student extraction of mathematical concepts from basic, ecosystem-related experiments and discussions. 5. To reinforce mathematical skills inherent in calculations involved in ecosystem study. 6. To apply math to the problems of ecology such as waste disposal, recycling, and conservation of natural resources.

OVERVIEW AND STRATEGIES:

My final unit will, as the title suggests, include a variety of lessons and activities which will incorporate both science and math. I intend to bring science into my classroom slowly and subtly with the help of the natural curiosity of my students. Each year I begin my curriculum with the reinforcement of the basic operations. While practicing this arithmetic, the students and I will discuss the application of math to other subject areas in school as well as to other areas in their daily lives. The students themselves will realize the role of math in the area of science. I plan on consistently communicating with the science teachers in my school throughout the year. At the beginning of the year, science and math teachers are charged with the task of teaching to the Connecticut State Mastery Test. Science teachers resent the time lost teaching their own curriculums in order to boost the city's scores on a standardized test. Since I am supposed to reinforce what is taught in regular math classes, at this time of the year I am to repeat what the students have done in already two of their previous classes. Last year was the first year of the science-math teacher effort to improve test scores. I learned that repeating the same material created the overkill effect coupled with disgusted boredom on myself as well as on my students.

My science-math integration unit will begin at the onset of the school year. The timing will not only relieve my students of their math overload, but will also help the science teachers from losing all ground in their particular implementation of their own curriculums. Science curriculum guides for the New Haven Public Schools specifically mention ecological topics at the beginning of each grade's scope and sequence: (see chart on next page)

Curriculum Guide for Science: Grades K-8

Grade	Units of Study	Expected Learning Outcomes for Students
5	Students will be able to:	
	Earth: The Water Planet	a. Explain, using examples, how ocean waters move and how this movement can influence the weather.
		b. Identify and describe some of the kinds of scientific equipment that are used to uncover information about the oceans.
		c. Identify food, minerals, and fuel resources obtained from the ocean, and explain why they are important.
Grade	Units of Study	Expected Learning Outcomes for Students
6	Students will be able to:	
	The Structure of	a. Infer the characteristics and properties of

	Matter	matter by observing and studying the elements of the air.
		b. Describe an atom and explain how atoms of different elements differ from one another.
		c. Explain, using chemical formulas; the kinds and numbers of atoms in a molecule.
	Energy in Your Life	a. Define energy and identify its different forms.
		b. Explain, using examples, how people depend on different kinds of energy.
		c. Explain the difference between renewable and nonrenewable resources and why conservation is important.

Grade	Units of Study	Expected Learning Outcomes for Students
7	Students will be able to:	
	Characteristics in Living Things	a. Describe the steps in the scientific method
		b. Make use of the metric system.
		c. Identify the characteristics and needs of living things and describe the process and basic chemistry of organisms.
		d. Explain the cell theory and describe the structures and activities of cells.
		e. Explain how living things are classified.

Grade	Units of Study	Expected Learning Outcomes for Students
8	Students will be able to:	
	Geology	a. Explain structure of the earth.
		b. Explain land forms.
		c. Identify and group rocks into the three major groups and briefly describe how each is formed.
		d. Identify minerals using scratch test, hardness scale, luster, crystal shape, etc.
		e. Explain weathering, erosion, deposition, uplift, deformation, isostasy.
	History of the Earth	a. Construct a timetable of the earth’s history in diagram form.
		b. Compare and contrast animal life of each era.
		c. Compare and contrast physical characteristics of plant eating and meat eating dinosaurs.
		d. Recognize and cite evidence for dinosaurs being unable to adapt to the changing environment.
		e. Gather data from the Mesozoic Era to present on the evolution of reptiles
		f. Describe fossil formation.
		g. Computer fossil age when given word probles dealing with radioactive carbon-14 dating.

All of these suggested units of study involve some aspect of ecology and can be projected into the study of ecosystems. Students will be inundated with mathematical concepts and arithmetic at this point of the year. The discussion of why they are doing all that math in regard to what they will be studying in science will help students understand the connection between science and math. Realizing this connection will give students actual, real-life procedures and concepts to which they can apply their math. I will also introduce the ecological basis on which all four units of study begin and from which my own science-math unit can emerge.

For example, the fifth grade science curriculum begins with the study of the earth as the water planet. I will discuss with students the amount of water on the earth. This discussion can incorporate many numerical concepts and attach real figures to real bodies of water. The students can than manipulate these real figures

with the four operations. Problem solving skills can then branch from these arithmetic manipulations. Discussion of bodies of water as ecosystems can then flow naturally out of our math-science study of water on earth.

The sixth grade science curriculum begins with the structure of matter and goes directly into energy. Discussion of different kinds of energy can lead into different kinds of measurement for the energy and can be calculated and converted mathematically. The energy systems of ecosystems can be derived from this energy study and will require more mathematical applications.

The seventh grade curriculum begins with the study of the characteristics in living things. Discussion of the needs of living things can lead into estimated calculations of amounts of food for people for any number of time frames. Then the needs of plants and animals can be discussed and their exact amounts of air, water, food, and sunlight calculated. The boundaries of a group of living things can be then introduced which is an appropriate introduction to the concept of ecosystems.

The eighth grade curriculum begins with the study of geology and then moves to the structure of the earth. These topics could lead into discussions of watersheds as ecosystems where the calculations involving input and output could be performed. When the history of the earth is discussed, the changes in the earth and environment could be discussed by quantity and numbers could be given to these quantities. Calculations could then be performed to discover the actual differences, sums, products, and quotients of objects on the earth both at the beginning of time and at the present.

Once the science teachers can resume their roles, those students who are in my class will have already had a head start in the topics they will cover in science. These students will also have a better understanding of the four operations because they will have used them in a scientific, concrete context. Most of my students enjoy science because of its manipulative and wondrous nature. Once their awareness of the strong connection between math and science is heightened, they will describe the many ways in which they have already used math in their science classes. Students will describe to other students in their science classes what they have been doing in math. After their science curriculum gets underway, they will describe and actually bring the science projects they will be currently working on into my classroom. The class as a whole will discover further ways to use math to derive more information from science and science will be realized as a way to put math to use.

I then plan to introduce a bottle biology project to the class. After the description of the project as an ecosystem and previous discussions of ecosystems involved in each class' initial units of science study, I will ask students to think about ways in which we could use the arithmetic operations they have been practicing while observing the bottles. The students will think of counting, estimating, measuring, and various manipulations of the four operations.

Students will be responsible for their own bottles and will be expected to keep a record of observations, calculations, and results. They will also write their own word problems and questions about their bottles which the rest of the class will answer and solve. I have done this activity in the past where students pretend to own their own business and write problems about the business which the rest of the class solves. I anticipate more success with the bottles because they represent a concrete example of life from which data can be observed and calculated and of which students will feel control and pride.

I expect discussions of the bottles to focus initially on what goes inside them. I would like to borrow scales from the science department so that each student could weigh the contents going in and then combined with

the weight of the bottles themselves. Students could calculate the differences between their bottles, get a cumulative weight for the class, and an estimated weight total for all the classes participating in the bottle biology project. Any estimate could naturally be compared to the exact measured total as well. Students could also weigh their bottles over time to determine if any matter is going in or out.

As students observe their bottles, they will be asked to keep a journal of their findings. From this journal, we will discuss what data could be graphed. The lengths of plant stalks, the amounts of water droplets on the bottles' sides are among some of the graphs I expect the students to construct. Because of the science-math introduction we will have had at the beginning of the year, I anticipate a lot of math to be generated from our first actual science experiment in math lab. Students will be already aware of the strong bond between math and science and will be able to extract math from science and vice versus. I am also still currently researching lesson plans which will be able to exemplify the science-math bond further and which will enhance the beginning of the year pre-integration process.

As the scale and complexity of mathematical applications on the bottles increase, so will the discussion of ecosystems. The classroom as an ecosystem will be the next plateau in the science-math integration. (See Lesson # 1.) The students will estimate and calculate the supplies needed to survive in the classroom for a day, a week, and a year. The students will understand the concept of an ecosystem and its boundaries after observing their bottles. This concept when applied to themselves personally will most likely frighten them and make them think of a multitude of supplies for the given period of time we are to plan within our own ecosystem. A discussion of the Biosphere II project will assist in our planning and prove that a self-contained environment is possible.

I will first ask students to compile a list of what they themselves think they would to survive in the classroom for one day. Once their individual lists are completed, we will make a list for the entire class. The numbers involved in this listing procedure will warrant limitless calculations, comparisons, and estimations. The idea of self-containment could also be projected for longer periods of time and for larger groups of people. We could take our list for a day and multiply to compute a figure for a week, month, and year. By increasing the time frame, students will undoubtedly realize that unforeseen, emergency situations will have to be planned for and provisions included in abridged lists of necessities.

Once we have exhausted the ecosystem concepts within the walls of the school as a boundary, we can move to larger boundaries and larger populations. The street on which the school is located could be the next ecosystem examined. In these extension exercises, estimation will be an essential skill although exact calculations could be made from initial rough estimate figures. The math department in New Haven is strongly in favor of the use of estimation to hasten mathematical procedures. Estimation has been proven to help the process of elimination while taking standardized tests. It is difficult to teach estimation as a mere arithmetic shortcut. By giving students real problems to estimate, their arithmetic will be improved for and towards a reason and goal.

The trends in current mathematics point toward more application and less "drill and kill". I have already mentioned how I believe my students will understand mathematical concepts in my unit because they will be putting numbers to objects or real life things and situations. Students, especially remedial students, work better when they work towards a specific goal or end and when they know the reason they are calculating or figuring something out. The current trend in mathematics is to give students one problem per class. I have recently tried this technique and it has changed my entire classroom. The students become almost obsessed with the dilemma at hand and a group of bored and hyperactive children becomes a cooperative, mature think

tank.

The ecosystem idea has thousands of these dilemmas inherent in it. I will pose these dilemmas to my students during the course of the unit and they will use their problem solving skills and natural curiosity to come up with solutions. For example, while compiling our lists, I will tell them that there will be no means by which we can cook or refrigerate food. The thinking of the students will shift and the quantities of various supplies will change as well. My point in this type of activity being that problem solving often does not have to include actual numbers and that to think well mathematically does not have to mean performing arithmetic well.

While discussing ecosystems of varying sizes, the exact studies of exact supplies will also be made in the same progression.(See Lesson # 2.) For example, scrap paper is a supply which the students take seriously for granted and consequently waste. Scrap paper will be saved for a week to first observe the actual quantity used. From this observation, many mathematical calculations can be performed. The total number of sheets; how much more or less is used according to grade or class; the average number of sheets used per class, grade, and student; and estimates of how much paper would be used for a month, year, etc. are some of the mathematical calculations that will be made.

Students will then measure and estimate the paper wasted by noting the unused portions and sides of each page. These estimated calculations could be projected for the whole school so that a conversation effort could be undertaken by each class. This effort could be an actual campaign made by each class which will in effect publicize the arithmetic the students have been calculating. It will also hopefully create a sense of pride in the students. They will be displaying the fruits of their mathematical effort and showing its applications by trying to foster a conservation effort. Actual costs of paper could be attained from down town. Students could determine the percent of the overall budget spent on paper and savings estimations could also be publicized as part of the conservation campaign.

Similar studies of the input/output aspects of ecosystems could be done for different areas of the school and of the homes of students. Since I have begun the study of ecosystems at the Yale Institute, I have noticed some input/output aspects in my own life. I use grocery bags as liners for my garbage pail. When I’m running out of bags to use as liners, I am usually running low on groceries. Students will most likely make such observations on their own from which more specific studies of quantities could be made. Questions such as why when garbage bags are running scarce is it time to buy more food and how is food intake and garbage disposal related? If students study the input and output of their own homes they will most likely draw different and varying conclusions and surmise theories about how more people of varying ages affect consumption and waste.

Exact studies of waste provide a wide range of ecological and mathematical ramifications. Students could observe what types of products are purchased in their households. (See Lesson # 3.) They could determine the percentage of plastic, non-recyclable refuse and paper or glass, recyclable refuse. Discussions of the dangers of non-recyclable products could preface such observations and calculations so that students will become aware of the necessity to recycle. If students do not recycle at home, perhaps they will begin to after they realize how much plastic they use at home and how detrimental it is to society.

I have mentioned many home situations thus far in this narrative. I think students bringing ideas home will spark the interests of their parents and prove to them that their learning is worthwhile and pertinent to their lives. Many of my students’ parents have admitted to me that they have never excelled at math. They have blamed their math phobia as the reason their own children are not proficient at math. The idea of proficiency has always meant the ability to calculate numbers quickly and correctly. I hope to extend this idea of

proficiency to include the applications of calculations to relevant issues in the lives of the students and their parents.

Once the students have studied the input/output aspects of their own homes and our classroom, this study can too be extended to different areas of the school, city, and state. In the school itself, the cafeteria would provide a vast array of observations and bring forth a multitude of math-science issues to manipulate. Waste of food as well as percentages of food both purchased and wasted are some of the more apparent issues. Recycling is also an area of investigation. The amount of food purchased, prepared, and thrown away could be noted and students could note any differences in amount of supplies purchased in a week versus the amount discarded.

The input/output aspects of the city and state could be studied by writing to agencies or officials for figures of refuse. There is a landfill near our school and perhaps we could take a trip there to discover its exact size and intake. This trip would emphasis the need to recycle and could be cause for students to think of alternate ways of disposing of garbage. Composting would be an alternative which could be discussed and even attempted by the students at home or even on school grounds.

I have been researching various experiments from the Aims Education Foundation Programs. Many of the experiments involve complicated equipment and extensive laboratory set-up. I do not intend to completely transform my classroom into a science classroom. My job is to reinforce math. My students require remediation. I have therefore come to the conclusion that I will build upon the ecological ideas emanating from the discussion and study of ecosystems. As my overview suggests, I will begin small and enhance the size and ramifications of different ecosystems. I have also described the many mathematical applications involved in such a progressive study of ecosystems. These applications will reinforce math and show students that math is relevant to their lives, environment, and futures.

Lesson # 1: No Way Out

Goal To help students comprehend the self-contained aspect of an ecosystem.

Objectives

1. Students will estimate the supplies needed to survive in the classroom for a day.
2. Students will calculate the amount of food, water, paper, oxygen, etc. to live in the classroom for a day.
3. Students will project the supply calculations for a day to a week and year and for populations bigger than their class.
4. Students will extrapolate from the concept of the self-contained environment of a classroom and apply it to global conservation issues.

Procedures (These will cover several lessons.)

1. Students will be familiar with ecosystems after observing their bottle biology projects and discussing the Biosphere II project. Students will then be posed with the scenario of not being able to leave the classroom for an entire day. They will be asked to compile a list of what they would need to survive for they day of imagined entrapment.

2. Students will share their lists in small groups and compile a group list. Encourage students to be reasonable and conservative. Emphasize numerical quantities in their listings. The group lists will then be shared and an overall class list will be formulated. Students will most likely overlook certain supplies. Remind students of these forgotten supplies such as oxygen, water, and paper.
3. Ask students how the class list of supplies for a day could be projected for a week and year. Double the class size and ask the students how supplies for the whole school could be determined for a day, week, and year.
4. Pose various problems to the students to see how their supply lists would change. For example, tell them they could not refrigerate or cook any food and that electricity would be limited. Encourage students to think of any resource problems that truly exist in the world today and to list ways to solve and remedy such problems.

Evaluation

1. Have students make posters of their group supply lists with a rationale for each item listed.
2. From the class list, have students calculate supplies for a week and year and for larger populations.
3. Have students write their own problems about the supplies, calculate their answers, and present their problems to the rest of the class.

Lesson # 2: The Paper Chase

Goal To heighten student awareness of waste by studying scrap paper and to encourage students to campaign for its conservation.

Objectives

1. Students will determine the amount of scrap paper they use in the classroom.
2. Students will observe the amount of scrap paper that remains unused and that is consequently wasted.
3. Students will recognize the need to use paper more efficiently and will launch a school-wide conservation campaign.

Procedures (These will cover several lessons.)

1. Students will save their own scrap paper for a week in boxes, folders, or envelopes with their names on them. They will then count the number of sheets they have used and compare this number with their classmates' numbers. The class grand total can then be calculated from which the average number of sheets used per student can be extrapolated.
2. From the calculations made for a week, encourage students to estimate larger figures such as paper used in a month and year and by larger populations such as each grade and all math classes in the school.
3. Ask students to measure the unused portions of their saved scrap paper. Encourage students to recognize patterns of their own consumption so that they can calculate a logical estimate of wasted paper space for a week. Students can then project their estimate to determine how much paper is wasted throughout the school.
4. The amount of money spent on paper can be attained from the city and students can determine the percent of the budget spent on paper. Students will then publicize their findings and estimates around the school in an effort to make everyone aware of the need to conserve paper.

Evaluation

1. Have students record their calculations in a journal. Encourage students to document their procedures and methods along with any reactions they may have to their findings.
2. Break students into groups of four or five students and have them discuss ways in which they can launch a conservation campaign in school. Make each group responsible for their campaign and each student accountable for a duty in the overall endeavor.
3. Have each group present their campaign and grade each group for originality, effort, and effectiveness. Award each group for its most striking campaign element and display whatever posters and visual products emerge from each effort.

Lesson # 3: Why Recycle?

Goal To make students aware of the need to recycle at home and in school.

Objectives

1. Students will recognize what products are recyclable and non-recyclable.
2. Students will determine the amount of recyclable and non-recyclable products used in their homes and at school.
3. Students will recognize how non-recyclable products could be replaced with recyclable products in many cases.
4. Students will understand the importance of recycling and promote it at home and in school.

Procedures (These will cover several lessons.)

1. Discuss what happens to non-recyclable and recyclable products with students emphasizing the dangers to the environment of non-recyclable matter. Ask students to look around the room and determine what has been or could be recycled and what cannot be recycled. Students will keep a log of things they see in school which are and are not recyclable.
2. Have students take their recyclable/non-recyclable logs home with them to list items in their refrigerators, kitchens, and other areas of their houses. Students could then calculate the percentages of both recyclable and non-recyclable items in their homes. Specific percentages of plastic, glass, paper, and styrofoam items could also be determined.
4. Students whose homes have high percentages of non-recyclable products will then think of how they can decrease their consumption of non-recyclable matter and increase their consumption of recyclable matter. Encourage students to discuss how they can recycle with their parents. Students can make the same calculations by observing the cafeteria at school and discuss ways in which the school can become more recycling-conscious.

Evaluation

1. Observe and read student logs.
2. Collect student calculations and have students calculate further percentages on their own.
3. Have students write contracts to pledge recycling at home and at school. Have parents and teachers sign the contracts as well.

4. Have students make checklists to attach to their contracts so that progress of their recycling efforts can be monitored periodically.

Teacher Resources

Aims Education Foundation. *Down to Earth* , ed. Weibe, Arthur et al, P.0. Box 7766, Fresno, California, 93747. 1987.

A series of books full of lessons integrating science and math skills. A good starting point for teachers to begin incorporating science and environmental issues into their math classrooms.

Allen, John. *Biosphere II; The Human Experiment* , Viking Penguin, 1991.

This book describes the experiment in the desert of Arizona in which humans are living in a self-contained ecosystem. Excerpts can be read in class with students to encourage them to contemplate the concept of containment within various hypothetical ecosystems.

Bottle Biology Project. *Bottle Biology* , Department of Plant Pathology, University of Wisconsin, 1630 Linden Dr., Madison, WI, 53706, 1991. (608)263-5645.

This pamphlet describes how to make mini ecosystems from plastic beverage bottles and explores ecosystem interactions and dynamics. It is a great place to find basic science experiments for non-science teachers.

The Center for Environmental Research and Service. *Alabama Pals Litter Education Activity Guide* , Troy State University, Troy, Alabama, 36082.

This booklet contains many lesson plans which integrate math with science, ecology, and other subject areas. The lessons address issues like waste disposal and household waste and encourage conservation and recycling.

Mead Corporation. *Kids C.A.R.E.: A Cross-curricular Environmental Program* , Courthouse Plaza Northeast, Dayton, Ohio, 45463. 1991.

This book is full of activities for children in grades 4-6 which is designed to actively help students reduce solid waste. The activities integrate math and science and focus on waste disposal.
