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Developing Environmental Awareness Through Problem Solving

Curriculum Unit 80.05.12
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Often, on my way to work, I walk through broken glass, empty cans, paper, and other debris scattered throughout the school yard. I watch young people walk around eating "junk food" and dropping the wrappers wherever they happen to be, with seemingly no awareness of the consequences of their actions. It seems clear that we have a pressing need for environmental education.

Environmental education is primarily based on the concepts of ecology, the science that deals with the interrelationships among living and nonliving parts of the environment. The work in this unit is planned to help students become more aware of their environment, of how they affect their environment, and how the environment affects them.

This unit is planned for use with 9 th and 10 th grade students as an interdisciplinary unit in a general mathematics course. The environmental objective is the increased student awareness mentioned above. The mathematical objectives are to stress the development of problem solving skills throughout the unit and within this framework bringing in as many of the ten basic math skills [1] as practical. A suggested strategy for problem solving skills and their significance are included in appendix.

I. *General Organization and Orientation of Unit*

The development of this unit falls into two parts. Part One: Developing Personal Linkage to the Immediate Environment and Part Two: Extending Linkage from the Immediate Environment to Earth's Natural Resources. The significance of individual action is to be stressed at all levels whenever possible.

Part One: Developing Personal Linkage to the Immediate Environment

Since we experience our environment primarily through our senses, this unit begins by taking an inventory of the things one can see, hear, smell, taste, or touch in the classroom. The purpose is to develop greater sensory awareness and to begin to make conscious the link between ourselves and the environment.

I think it is important to notice several things here. First, our conscious linkage with the environment is primarily through our senses. Secondly, human senses have an incredible range of capabilities. The eyes see all kinds of colors, shapes, and movements. Our ears hear soft whispers, beautiful music, and deafening noise.

The sense of touch can appreciate fine silk and rough bark, degrees of coolness and warmth, distinct shapes and freeflowing forms. The senses of taste and smell each has a range of subtle to gross capabilities and so on. Third, in our schools we traditionally have emphasized verbal communication. Verbal communication requires very limited use of senses. The eyes are asked to read the printed word or study the diagram if it be in a textbook, on the blackboard, or on the overhead projector. The ears are asked to “listen” generally meaning to tune into what the lesson is about. The point is that there is a full range of sensory abilities we can call into use, develop, and fine tune. It is part of more fully experiencing life. I think the time has come for this to be consciously incorporated into our school activities.

There is one other aspect to be mentioned here. It is the idea of having people “actively participate in life.” This is a matter of degree. It is also a matter of freedom. When one is more or less confined, self-imposed or otherwise, to limit one’s activity to receiving certain words and images be they in school or at home in front of a television set, that person is “actively participating in life” at a fairly low level. He is able to give little of himself. When he climbs a tree or has to solve a problem that is relevant to him and with which he must struggle, then he is “actively participating in life” at a higher level. He is able, and required, to give more of himself, and he will get that much more from it in understanding and appreciation. This seems clearly related to young people who walk around “eating ‘junk food’ and dropping the wrappers wherever they happen to be, with seemingly no awareness of the consequences of their actions.” The average American student, upon graduation from high school, will have spent 11,000 hours in school and 15,000 in front of a television set. [2] This, too, is being realized in many of our schools. So this first part asks students to use sensory awareness in reaching out toward the environment and to work abstractly with what they find there. The second part extends this.

The inventory begins by making a list of the items students come up with, then the list is developed into a table from which data is extracted for use in various ways with basic math skills. The first lesson plan below gives further detail on this. It will probable take one or two class periods depending on how students respond and to what degree the math ideas are developed.

Part Two* : *Extending Linkage From the Immediate Environment to Earth’s Natural Resources

This section takes one item from the environment, electricity, and traces it back out of the classroom to how it was developed from use of natural resources. Work here would include dealing with quantities consumed, resource limitations, pollution, measurement, and cost. The second and third lesson plans are part of this section.

II LESSON PLAN

Part One Developing Personal Linkage to Immediate Environment

First Lesson Plan

Since only through our senses can we experience our environment, this unit begins by calling attention to the use of our senses.

1. Have students look around room to notice what things are in the classroom.

2. Ask class for things that they see, hear, touch, taste, or smell if possible list some items in each category. About 15 would be enough.
3. Develop list into a table by asking for information that calls for further use of senses. Figures 1 and 2 indicate the approach. Students are asked to name items in the environment, then use senses of reason, sight, and touch to decide if item is natural or human made, what the color is, and if hard or soft.
Figure 1.

(figure available in print form)

Figure 2.

(figure available in print form)

4. Having generated a table, the next step is to use the data in it. Introduce a clearly stated problem.

"I have a problem. I want to know the ratio of natural to human made items on our list. Who can tell us what ratio means?"

Once the meaning of ratio is clear, everyone probably will see the answer and someone will say, "3 to 12". Practice as needed having students state different ratios such as number of hard to soft, soft to hard, green to beige, etc. Within this time the definition of ratio (comparison of two numbers), the symbols for writing ratios (a:b or a/b) and that we usually write ratio in simplest form would have been covered.

"I have another problem. What percent of the items on our list are natural?"

This will not be easy for general math students. "What does percent mean?" Someone will probably say, "Per 100." All will then be quiet. "What was the ratio of natural items to human made items?" "3 to 12." Questions will probably go along the line, "Can knowing it's a ratio of 3:12 help us find the percent?" "Is 3:12 in simplest form?" "Oh, i:4 is the ratio of natural to human made items, that means 1 per 4, but percent means how many per hundred. Is there anyway we can use this idea?"

At this point, depending on the class, we might work with another table like the following one.

1 per 4	natural	human made
2 per 8	1	4
3 per 12	2	8
	3	12
	4	16
	¥	¥
	¥	¥
	¥	¥
	25	100

Or we might work with proportions if the class background will allow it. Either way, once we get the 25% we need, it probably would be helpful to compare with illustrations since students are generally very weak in this area. Possible illustration would be as follows. Let three students fill in the circles with division marks and shading.

(figure available in print form)

5. *Assignment* . The assignment would be a worksheet with a blank table at the top for students to take home and fill out items they find in one of the rooms at home and information about items, (2) a section to write ratios based on information they gathered and (3) a section on straight math practice according to level of class possibly only writing and simplifying ratios or else an entire range from writing and simplifying ratios to difficult proportion and percent exercises. Students will have basic skill books to use and the last part will only require listing certain pages and exercise numbers.

6. Note. Since real life is usually a complex experience, trying to fit even simple real life situations into a mathematical structure can present problems. Light in the classroom is both nature (sunlight) and human made (electrical). The chart has a place for the color of electricity, but this is not an appropriate question for electricity. The same would be true for asking if the smell of food from the cafeteria is hard or soft. The point is that we will have to learn to deal with the often not quite perfect fit between data from real life situations and a mathematical structure if we want the mutual enhancement such action allows.

Part Two : *Extending Linkage from Immediate Environment to Earth's Natural Resources*

I. *Second Lesson Plan* : Where Does our Electricity Come From?

Very helpful in developing teacher background and student activities for this section are *Teaching for Survival* by Mark Terry, *The Ecology Action Guide* by Alan Bock, and *A Short Energy History of the United States* by Joseph Dukert.

A. Beginning Discussion. 1. Review original work the class did to produce the table of environmental items and how it was used with math concepts. 2. Have a discussion in class concerning energy until the idea that energy is the ability to do work or to affect change is established. 3. Discuss what kind of energy we have in class. Sun, people, and electric energy might be brought up. 4. Focus on electric energy. Where is it located? Light switch and outlets. Be sure it is clear that potential electric energy is sitting right there waiting to go to work the moment we flick the switch or put in the plug. 5. What is electricity? Discussion should bring out that electricity can be described as a continuous flow of electrons. The rate of the flow is about 186,000 miles a second the equivalent to travelling 7 1/2 times around the Earth in one second. Thus when we turn on the switch we allow for a constant flow of electrons which creates the energy to turn on the lights or do other work.

> B. Stating a Problem. “Now if potential electric power is sitting right here in this room, st that switch and that outlet, how did it get there?”

Here it might be helpful to suggest, “Suppose we were tiny creatures who could travel along the wires that lead sway from our room back as far as we can to see just where our electricity is coming from.” Eventually the discussion should end by being able to generate a flowchart such as is illustrated in Figure 3.

(figure available in print form)

Figure 3. Where classroom electricity comes from.

Since I want to use Polya’s four steps in solving problems as a guide throughout this unit, I want to analyze problems for myself and the students along these lines. Here is an example of analyzing a problem for my own guidance in coordinating the discussion. After the flow chart was completed, we would then take a minute to relate Polys’s steps, listed on a permanently displayed chart, to the problem completed.

Step 1 : *Understanding the problem* . What is the unknown? Where the electricity comes from. What is the data? We have to develop data from the class. How far back do we want to trace it? To the plant? To the natural resources it comes from?

Step 2 : *Devising a plan* . I want to develop a flow chart method.

Step 3 : *Carrying out plan* . Develop the flow chart through discussion.

Step 4 : *Looking back to check results.* Look back at the original problem, is the answer clear? Is it reasonable? Do students know that electricity is produced in a plant that requires fuel, water, and air to operate?

Carrying out plan, step 3, is the most significant part. How this is done could determine significantly the quality of learning that takes place in the unit.

The illustration work might begin like this. “Ok, here we are, sitting in this classroom.

(figure available in print form)

We said that potential electrical energy is right here at this light switch and that outlet. The question is how did it get there?” Someone will probably say “From the electric company.” And you can ask, “But how did it get from there to here?” Someone will say something like it was transmitted by wire, and, at that point, the illustration looks like this.

(figure available in print form)

Before continuing it might be worth briefly mentioning the materials used in making wire and something about where those materials come from and about the estimated world supply of them. This would begin the pattern of thinking along these lines.

The next step would be something like this. “Ok, now we have traced the electricity back by wire to where it comes out of the electric plant. The next thing we need to know is what happens in the plant to produce the electricity.”

How this goes will depend on the class, but certain ideas should be included. How is electricity produced? Perhaps an illustration off to the side illustrating a rotating magnet inside coiled copper wire would be helpful. Since this produces, generates, electricity we now include the generator in the illustration. What turns the magnet at the power plant? This will get us to the turbine. What turns the turbine? How? Where does the steam come from? How does the boiler make steam? Is that steam different from the steam you could make if you put a pot of water on the stove and heated it? It probably would be helpful to suggest that later we want to find out what happens to the air and water while it is in the boiler and when it leaves. Also, we want to know a lot more about that fuel. What kind of fuel is used? Exactly where does it come from? What happens to it?

C. Assignment: (1) Study the flow chart and be able to draw it from memory. Test students on this at beginning of next class. (2) Read *Exploring Electric Energy* and answer the following six questions: 1. What things must go into the boiler? 2. What comes out of the boiler? 3. What does the turbine do? 4. What does the generator do? 5. What does the electric company store in the two 13 million gallon tanks? 6. What percentage of construction cost went to environmental concerns?

II. *Natural Resources and Environmental Issues* . Area to be covered between second and third lesson plans.

A. Using the flow chart, discuss where each of the three resources, air, water, and fuel comes from and what happens to it during its use at the plant and after.

B. Discuss the point that the fuel could be oil, coal, or nuclear energy, they all would be used to heat water to make steam to turn the turbines.

C. Look at the flow chart and ask if anyone can see any possible environmental problems that might come up with the production of electricity. The following areas should be included in the discussion. i. Where does the oil come from? How does it get here? 2. What are some problems in using oil as the fuel for producing electricity?-air pollution, oil spillage, and depletion of world supply. 3. What are some problems using coal as fuel? mining difficulties and dangers, air pollution, storage and transportation of coal, where to put the ashes, and a limited supply of coal. 4. What are some of the problems using nuclear energy as fuel? safety in operation and disposing nuclear waste. Connecticut Environmental Protection Department and Connecticut Citizen Action Group could be helpful in developing this section. Both groups are based in Hartford.

III. *Third Lesson Plan* . How to Read Your Electric Meter, Determine Amount of Electricity Used, and Calculate Your Bill.

A. Beginning Discussion. The electric meter in each house keeps track of how much electricity a family uses Have a fairly large piece of cardboard with five circles with appropriate digits and moveable dials. See Figure 4.

(figure available in print form)

Figure 4. Most electric meters are organized like this. The rightmost dial indicates kilowatt-hours used, the next dial indicates tens of kilowatt-hours, the next hundreds of kilowatt-hours, and so on.

B. On the overhead projector show three sets of meter dials and the reading for each. See Figure 5. Let students quietly study them. They may work alone or with another student. Ask them to quietly raise a hand when they think they understand how the readings are done.

(figure available in print form)

Figure 5. [3]

Using cardboard model let several students read settings that you arrange.

Ask students what might make reading the meter tricky. They will probably point out that (1) some of the dials read clockwise while others read counterclockwise and (2) when a dial is between two digits, you have to read the lower one.

C. With cardboard model, demonstrate how dials would move as electricity flowed through meter. Next, on the blackboard, write down a given reading from model. Suppose electricity flowed through the meter and make the dials move accordingly. Then stop and write that reading on the board. The problem becomes: “How many kilowatt hours of electricity were just used?”

Let students work alone or together but make them come up with some answers before the class as a whole establishes that it is the amount of change, the difference between the two readings that we need to determine. Put a prepared transparency up to provide additional practice and afford the opportunity to check students’ understanding individually.

D. Assignment: Complete a worksheet that has two sets of dial readings, from the same meter, one month apart. The problem is to determine the amount of kilowatt-hours used, then determine the bill for that house. They are to work with determining a bill by themselves before we do it together.

The UI publishes a small card titled “how your electric bill is computed.” Students would be given one of the cards, if available, or the following information from it would be on the worksheet.

Residential Rate R:

For electricity delivered each month

$1.5409 including the first 10 or less kilowatt-hours

Next 40 kwhrs.	7.2238c per kwhr.
Next 100 kwhrs.	6.4575c per kwhr.
Next 250 kwhrs.	5.3196c per kwhr.
All additional kwhrs.	5.0758c per kwhr.

Let’s say that last month you used

550 kilowatt-hours.

Here's how your bill would be computed:

First 10 kwhr.		= $ 1.54090
Next 40 kwhr. (40 x 7.2238c)		= $ 2.88952
Next 100 kwhr. (100 x 6.4575c)	= $ 6.45750	
Next 250 kwhr. (250 x 5.3196c)	= $13.29900	
Remaining 150 kwhr. (150 x 5.0758c)	= $ 7.61370	
Total kwhr. = 550 Total bill		= $31.80062
(roundest to nearest cent)		$31.80

The next two days would be used determining bills. Hopefully, we will be able to use some of our own UI bills.

IV. Conservation

Begin this section by listing ways we use electricity in our daily lives. Then discuss such topics as the meaning of conservation, should we conserve, why or why not.

Assignment. (1) Read *Tips for Energy Savers* . (2) Write a list of ten suggestions you and your family might use to cut down on the use of electricity. (3) Locate your electric meter and write down its reading.

Final activity of unit. After students have written down the readings on their meters and the date it was taken, they are to plan to take three more readings, each one week apart. During the first week we will discuss the suggestions students listed for saving electricity and at the end of the week, each student is to discuss with his/her family what suggestions they would be willing to seriously try. Over the next two weeks everyone is to make a concerted effort to cut down on their use. At the end of each week students will bring in readings, put it on a chart and calculate the number of kilowatt-hours used. Hopefully we will have a positive observable difference. The information in figure 6 would be helpful in evaluating suggestions and deciding which should be given priority.

Annual Energy Requirements and Costs

for Common Household Appliances [4]

Annual

Appliances	Annual kwhr Consumption	Operation Cost 6c/kwhr
water heater	4,219	$253.14
refrigerator	2,250	135.00
freezer	1,820	109.20
clothes dryer	993	59.58
range	700	42.00
color TV		
tube type	528	31.68
solid state	320	19.20
lighting	360	21.60
black and white TV		

tube type	220	13.20
solid state	100	6.00
washing machine	103	6.18
vacuum cleaner	46	2.76
toaster	39	2.34
clock	17	1.02

Figure 6.

During the last two weeks of the unit, while at home students are trying to reduce the amount of electricity used, in school they will be working with a variety of environmental problems and related math skills. Careers related to the areas covered will be discussed. After the last readings are in, individual and class efforts will be evaluated.

Though I do not plan to use either in this unit this year, two potentially exciting activities could be included. The first is a filmstrip of the construction and functioning of the New Haven Harbor Station which would be followed by a tour of the plant. The second is a simulation game called Energy/Environment Game. In it there is a film strip, research material, and role playing representing people from (1) the electric company, (2) conservation and environmental groups, (3) commerce, industry, and the professions and (4) residence. I can see beginning with game and expanding it to include people in the community. The game is put out by United Illuminating.

Notes

1. The National Council of Supervisors of Mathematics identified the ten basic mathematic skills needed by today's students as (1) problem solving, (2) applying mathematics to everyday situations, (3) alertness to the reasonableness of results, (4) estimation and approximation, (5) appropriate computational skills, (6) geometry, (7) measurement, (8) reading, interpreting and constructing tables, charts, and graphs, (9) using mathematics to predict and (10) computer literacy. National Council of Teachers of Mathematics. *An Agenda for Action: Recommendations* for School Mathematics of the 1980s. NTCM Inc., Reston, Virginia. 1980. pp. 6-7.
2. Fisk, Edward B. 1980. "Values Seen in Conflict," *New York Times* , April 20, Section 12, p.1.
3. *Energy Conservation Experiments You Can Do* . 1978. Thomas Alva Edison Foundation, Inc., Springfield, Michigan.

Teacher References

Bock, Alan. 1971. *The Ecology Action Guide* . Los Angeles. Nash Publishing. Generates one good action idea after another.

Dukert, Joseph M. 1980. *A Short Energy History of the United States* . Washington, D.C. Edison Electric Institute. Views the history of the United States from an energy orientation rather than social or political.

Miller Jr., Tyler G. 1979. *Living in the Environment* . Belmont, California. Wadsworth Publishing Company. Comprehensive reference book. Very helpful.

Polya, G. 1957. *How To Solve It* . Garden City, New York. Doubleday and Company, Inc. A classic book on problem solving.

Terry, Mark. 1971. *Teaching For Survival* . New York Ballantine Books, Inc. Excellent for generating many environmental study possibilities related to daily life and especially everyday life at school.

Student Reference

United Illuminating. 1976. *Exploring Electric Energy* . New Haven. Gives basic facts about electricity and the construction of the New Haven Harbor Station. Also available in Spanish.

U.S. Department of Energy. 1978. *Tips for Energy Savers* . Washington, D.C. A 29 page booklet that discusses energy saving.

Appendix

Developing A Problem Solving Strategy And The Reason It Is Important

William Ryan, in *Blaming the Victim* , defines power as the influence or control one has over ones life and environment. Power is an overriding human concern. What we can make happen by our own will and action significantly determines the quality of our existence. The absence of power causes apathy, fatalism, depression, and pessimism. [1] Developing confidence in how to solve problems, how to make known that which was unknown to you, may sound distant from any serious talk about power, but it isn't. It is a crucial tool needed by young people as they struggle to get control of themselves and try to find a satisfactory way of functioning in society. It can help them earn confidence in themselves and their culture. We, as teachers, are being informed by testing [2] both at the state and national level that our students are weak, or lacking, in problem solving skills, We are continually being asked by administrators to stress the development of this skill. Much is being published in this area. A few practical suggestions for developing a problem solving teaching strategy follows.

In his article, "Students Can Learn to be Better Problem Solvers," Arthur Whimbey [3] states that two characteristics which distinguish successful problem solvers from unsuccessful problem solvers are (1) a step-by-step approach and(2) carefulness. Research indicates that small discussion groups are helpful in developing these skills at all ability levels, but are crucial at the lower ability lever. Other suggestions from this article are to try to get other teachers in the school to stress accuracy and to cue parents in to some supportive ideas.

Continuing with the idea of small group discussions, an article in the New York Times [4] reported good results being accomplished under the guidance of teacher David Lazerson, at the Martin Luther King Jr. Community School in Buffalo. “The Talmud teaches that if you don’t learn out loud with someone else, you’re not learning,” states Mr. Lazerson. This method of learning was supposedly given to Moses on Mount Sinai 3,000 years ago. It was used significantly in Mr. Lazerson’s education and he uses it in his teaching. Students, in pairs, learn by discussing out loud, and when a student becomes competent in a certain area, he is encouraged to tutor younger students. He has used this method successfully with LD students and in an inner-city school of 700 students.

The ideas of Reuven Feurstein’s instrumental enrichment seem worthy of mention here. He is concerned not with what students have learned, but how they learn and solve problems. He has devised a formal instruction program (Feurstein Instrumental Enrichment, or FIE, program) which identifies fourteen “instruments”, or skill areas in cognition. The first instrument in the curriculum is concerned with organizational skills. If a student has difficulty in this area, the teacher “mediates” with the instrument materials. The purpose of the FIE is “to change the cognitive structure of the retarded performer and to transform him into an autonomous, independent thinker, capable of initiating and elaborating ideas.” [5] His work indicates that learning ability can significantly improve at all ages. This method might offer help for some of our seemingly capable but not performing adolescents. Feurstein developed this method in Israel while trying to assess the cognitive ability of children coming from very diverse cultural backgrounds.

Polya’s *How To Solve It* is probably the most familiar book on problem solving. He divides problem solving into four areas: (1) understanding the problem which means one can answer such questions as “What is the unknown?, What are the data? What is the condition?”, (2) devising a plan possibly by using related problems from past experiences, (3) carrying out the plan of solution and checking each step and (4) looking back to check the results, check the reasoning and consider if there might be another way of doing it.

How can these ideas be integrated into a problem solving strategy that would be helpful in the everyday classroom? The ides of small group discussions and students helping each other learn are certainly not new techniques, but I have made very little use of them and am not aware of any of my colleagues doing so to any significant degree. For two students to learn by discussing the material out loud together might be relatively new to most of us and might possibly be extremely useful in certain situations. The technique, of talking things out with another person, is usually helpful in both clarifying ideas and increasing understanding wherever it is used. To develop a step-by-step approach and the habit of being careful would require using a step-by-step approach, such as Polya offers, and doing so very carefully, over and over, day after day, all through the year whenever it could naturally be used.

The Feurstein instruments attempt to map cognition and possibly could prove helpful, but they require considerable study on the part of the teacher. The strategy that seems to make most practical sense in working with problem solving is for the teacher to develop proficiency in using a step-by-step method and to use this method fairly consistently throughout all problem solving. Simultaneously, as the situation allows, one can try out the techniques of small discussion groups, student-teaching-student, and learning out loud in pairs.

Appendix Footnotes

1. Ryan William. 1971. *Blaming the Victim.* New York. Vintage Books. Random House. p. 242.
2. Carpenter, Thomas P., Cobitt, Mary Kayl, Kepner, Henry, Lindquist, Mary Montgomery, Reys, Robert E. 1980. “Problem Solving in Mathematics: National Assessment Results.” *Educational Leadership* . Alexandria, Virginia. April.
3. Whimbey, Arthur. 1980. “Students Can Learn to Be Better Problem Solvers.” *Educational Leadership* . Alexandria, Virginia. April.
4. Lipman, Steve. 1980. “Talmudic Ideas Used in the Ghetto.” *New York Times* . April 20. Section 12. p. 22.
5. Hobbs, Nichoas. 1980. “Feurstein’s Instrumental Enrichment: Teaching Intelligence to Adolescents.” *Educational Leadership* . Alexandria, Virginia. April.