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Saving Energy Makes Cents

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A few months ago, shortly before our Christmas vacation, I was having lunch in our faculty lounge with several of my colleagues. Typically, we would use the kitchen sink to wash up before our noonday meal, and although we would consciously try to shut off the hot water faucet, it would continue to drip. At various times, it would leak more than others depending on the pressure exerted on the closure lever by different school personnel and as we sat there having lunch, the dripping facet would become a daily topic of conversation. It just seemed incredible to us that given current concern for energy awareness and energy conservation that this hot water faucet would continue to waste energy and taxpayers dollars without anyone giving such “small problem” a second thought.

After we returned from our Christmas vacation, our faucet not only continued to drip but now it had increased to a steady flow of hot water. It was then that we realized that our small problem was really emblematic of a much larger problem and that this would provide our science class with a unique opportunity to get involved with a “first handed” science project that not only would teach us valuable conservation methods but also allow us to make recommendations to our Clemente School Planning and Management Team as to reducing energy waste in our building.

After carefully selecting an investigation team comprised of four eighth grade students, we calculated the approximate water loss from the faucet daily, both before and after the lunch time crowd, for a period of ten days. We used an empty quart soda bottle and a stop watch, graphing our daily results on flow charts. At the end of our testing period, we had accumulated some staggering data. From that single hot water faucet, we were losing approximately one quart of water every three minutes . . . that’s approximately twenty quarts or 5 gallons per day and approximately forty four thousand gallons per year, assuming that this condition was allowed to continue without repair. Compounding this problem, all this water had to be heated and additional cost was incurred as this wasted water was transported to the area sewage facility. After speaking with several staff members and building administrators, the faucet was finally adjusted and new washers were installed, saving New Haven taxpayers additional moneys.

Subsequently, this year I’ve decided to develop a curriculum unit that focuses on energy conservation as it directly relates to our physical plant at Clemente. We will concentrate on analyzing utility usage involving the South Central Regional Water Company, The United Illuminating Company and the Southern Connecticut Gas Company. In a time of major budget constraints, the rationale for this unit might allow us to reallocate any moneys that can be saved with energy conservation methods to programs that will enhance the educational opportunities for our students.

Specific lesson plans will emphasize “hands-on” experiments with measured expenditures of energy, research to identify potential problem areas and to make recommendations to remedy the problem situation, invitations to guest speakers from each of the local utility companies, and because our class is self-contained, we will engage in an interdisciplinary form of learning as we research the histories of these local utilities, correspond with their representatives both orally and in written form and conclude our unit with individual student assessments of their energy expenditures in their respective homes. Hopefully this unit will serve to create a greater awareness among our students and staff alike. It is a lesson that I hope our students will practice throughout their adult lives.

II. Goal, Objectives and Strategies

This year my primary objective is to help my students develop a higher level of energy awareness and to better understand the major impact that their own behavior will have on local conservation efforts. Additionally, we will learn how to become good consumers of electricity, water and gas as we complete individual assessments of our own homes. As the unit develops, we will learn more about how electricity is made, measured and used and we will transfer that knowledge to reading and understanding our utility bills.

At Clemente School, we will complete an overview of existing energy use systems and building design. We will consider new and creative ways to use the facilities which will result in large energy savings with low or no cost improvements. We will assist in creating public energy awareness because everyone needs to be involved in order to control the school’s daily energy consumption. Subsequently, our students will learn new problem solving techniques as they become involved in experimental teaching projects. These projects will incorporate oral and written presentations. All of these experiences will present our students with the opportunity to explore and the best explorations are accomplished with first handed experiments.

Keying on the various exploration possibilities, our strategies will allow our students to immerse themselves in the scientific method process, gathering information, stating hypotheses, designing experiments, making observations and recording data, organizing and analyzing this data, and suggesting future experiments and new hypotheses. Our studies will become interdisciplinary as we study new vocabulary and present oral and written reports in English, make observations based on comparisons and employ critical thinking in Science, study the economic impact of energy cost savings and the global impact of the conservation of natural resources in Social Studies, and finally, compute measurement statistics especially important in mathematical problem solving. I feel that our strategies will be most effective in motivating our students, improving their academic skills and their consciousness of the critical importance of proper energy management for our school and our future. Teamwork and problem solving will become our primary focus as we work together towards reducing the energy waste in our physical plant.

III. Understanding More About Electricity, Water, and Gas Resources

What is electricity? Can you see it or touch it and if you can't, then how do you know it exists? The answer lies with the effect that electricity produces. You can't see electricity but you can see the work that it accomplishes. Electricity can be described as a flow of electrons that travel at a rate of 186,000 miles per second. It produces heat and light and power for household appliances and industrial machinery. Because electricity is so versatile, it has become a major source of energy today. Electricity itself is not a source of power. Electrical power stations burn coal or other fuels to produce steam and it's this steam that produces the energy to power generators that produce electricity. Hydroelectric power stations use waterfalls as energy sources with nuclear power stations producing energy as well.

In traditional steam power plants, energy is produced when oil or coal is burned to heat water which converts to steam which in turn powers huge turbines. These turbines produce energy which enables generators to produce electricity as a result of their interaction with magnetic fields within the generators themselves.

Nuclear power plants operate in a similar capacity except that uranium is used in lieu of coal or oil. In this process of nuclear fission, the splitting of the atoms into lighter elements releases heat and the free neutrons, interacting with other uranium nuclei, allows the process to continue, the released heat causes the water to boil, producing steam, which ultimately produces electricity.

But enough about the production of electricity. Let us move to electrical usage in our homes and schools with particular emphasis on electricity recorded by electrical meters. In order to understand the functions of electrical meters, we need to understand specific units which are used to measure electricity and their relationships to each other. A Volt is the unit which measures the potential difference between two points on a circuit. The current, in most household and school receptacle outlets, runs at a constant pressure of 120 volts. As the current moves from the supply wire through the appliance or light, it loses voltage. When the current leaves the load unit and enters the return circuit, it has expended all its voltage. An ampere is the unit used to measure current, that is the number of electrically charged particles called electrons, which flow past a given circuit point each second. Current which has lost its voltage still has an amperage as it completes its circuit and returns to the power plant.

Watt is the unit of power. It indicates the rate at which a device converts electrical current to another form of energy, subsequently consuming that energy. Kilowatt-hour is the unit of energy measuring the total amount of electricity that is consumed. The relationship of volts, amperes and watts to one another is expressed in a simple equation that enables us to make any calculations needed: Volts X Amperes = Watts. If your current is 120V and an appliance requires 5 Amps of current, then the equation would read: 120V X 5 Amps = 600 Watts. Similarly, to estimate the current needed for an appliance rated in watts, one would simply turn the equation around: Watts Volts = Amperes. For example, if you had an appliance such as a microwave that used 2400 watts, the equation would read: 2400 Watts / 120 V = 20 Amps.

Having introduced our students to the basic concepts of electricity and the functions of specific units which are used to measure electric usage, practical learning experiences using simulated meters provided by the local utility company will enhance their learning experiences. Hands on activities, as previously noted, will facilitate their learning processes. Our local electrical utility willingly provides guest speakers to introduce this material. Additionally, pamphlets such as "You and Your Electric Company" and "How to Understand Your Electric Bill" and "How to Read Your Meter" will be provided and discussed to help students record daily meter readings at home and to calculate monthly electrical consumption. Students might consider drawing their own electrical meters complete with individual measurement expenditure dials to reinforce their understanding of the pamphlet information. They might also consider inventory assessment lists of primary electrical appliances in their own homes, identifying high, medium, and low energy consumption devices by multiplying the kilowatt hour cost by the number of kilowatt hours that the appliance uses. In this way, students will begin to realize how energy is consumed daily, monthly and yearly and subsequently, they can begin to become more responsible for their use or abuse of electrical energy. Together with their parents and other family members, they can embark on a conservation program that hopefully will extend to other utilities which are used in the home and perhaps, this learning process will extend to cooperative monitoring of energy uses at Clemente Middle School as well.

The pamphlet "How to Understand Your Utility Bill" should be assigned as homework for parents and students alike. The material covered includes terms such as the B.T.U., cubic feet, watt, kilowatt, fuel adjustment cost, and rate schedules. Major topics are "How to Read Your Electric and Gas Meters", "How to Apply Your Meter-Reading Skills," "How To Understand Your Electric and Gas Bills" and "Energy Costs of Major Home Appliances." The pamphlet itself is easy reading and subsequently, self-explanatory.

Every year, the world wide demand for electricity increases. In the Unites States we use approximately four hundred times as much electricity as we did in 1900 and roughly twelve times as much since World War II. And as we approach the 21st Century, our demands for electricity are ever increasing. Therefore, it behooves all of us to do our part in helping to conserve our natural resources. There's an old expression that goes "charity begins at home" and I'd like to paraphrase that statement just a bit to suggest that conservation of energy begins at home as well, and hopefully our students can make a real difference for their lives and the lives of their children.

IV. Clemente Middle School's Energy Designs

Roberto Clemente Middle School was constructed in 1977 in New Haven, Connecticut. It sits in the Hill district of the city and it is currently the learning environment for approximately nine hundred intermediate level students, receiving instruction, guidance and leadership from three principals and approximately seventy-five teachers. The physical plant is a large facility divided into three house areas. Having taught at Clemente for the past seventeen years, I'm as familiar with this building site almost as well as my own home. And understanding this familiarity with our complex site brings me to the realistic conclusion that implementing an energy—efficient savings program will pose a difficult challenge for our population given the large numbers of people who use our building Monday through Friday (almost one thousand) and given the design of the physical plant itself with the numerous exit/entrance doors (26), the case adjustment widows (116), sky lights (24), windows and an open area loading dock. But, however great the challenges, the opportunities to conserve and to save will most rewarding because we will make some changes, we will become more aware of our responsibilities in using our natural resources, and we will be able to make direct applications of these concepts in our daily lives. Moreover, students and teachers through out the city and the world(on internet) will be able to learn from our experiences.

The school building is a good place to start an experimental science unit because it is easily accessible, and it provides an inexpensive system to research. From an energy conservation perspective, students can study electrical maintenance, water and sewer expenditures, gas and oil consumption and the effect that human awareness and involvement has on controlling efficient levels of energy usage while maintaining adequate levels of comfortability.

Our first step in our classroom project will be to take an energy audit of our building. An energy audit is a scientific analysis of energy expenditures in a building. An auditor needs to have a knowledge of heating systems, building materials, and building use patterns. James Crenshaw, our building engineer, has agreed to work with us to discover areas of energy waste. He has agreed to share with us the physical and mechanical blueprints of Clemente School and to briefly explain them to us in a slide presentation. (He will have previously photographed the large scale prints).

Next, our committee classroom members will address teachers, (Special Planning and Management Team personnel) and students alike (student council members who represent individual classrooms) with informative workshops in an effort to involve building users in our conservation program. Our initial focus will be to reduce our electrical energy consumption. State regulations mandate that individual classrooms must have a minimum of fifty candle power lighting conditions. Many of our classrooms tested out at well over those minimum levels because of the numerous windows through out our complex. Although these windows provide additional light, the benefit is really a double—edged sword because for all the extra light that we receive, we also suffer a considerable amount of heat and air conditioning loss. A light meter which retails for approximately forty-five dollars is a very effective tool for determining the lighting levels in classroom settings. Perhaps arrangements could be made to have copies of Clemente's electrical billings shared with our committee members each month so that we could ascertain percentages of decreased or increased consumption. These reports would serve to give us a better handle on the effectiveness of our conservation efforts.

Custodial help in our study is a key component. Their help will be elicited to remove excess lights and ballasts to bring lighting conditions down to new state recommended levels. They will also monitor oil usage closely by checking to see that building temperatures are always set back one hour before the close of school daily. At monthly meetings with their New Haven Board of Education maintenance supervisor, they will receive instructions on how to manage their heating systems most efficiently. On days when warm temperatures are forecasted, furnaces should not be turned up to sixty-five degrees in the morning, anticipating that the sun will warm the building sufficiently. Additionally, furnaces should be cleaned on a regular basis and air conditioning should be limited to occupied areas of the complex only.

Our classroom committee members will play a vital role in managing our water consumption as they will monitor our sinks, toilets, and faucets on a daily basis, canvassing for leaks or broken equipment. Routes and checklists will be designed and two person teams will be assigned and rotated to monitor this situation. These teams will also check to secure our entrance/exit doors to help with our air infiltration system.

Art class projects designing informative energy conservation posters will help to remind our building users of the vital importance of their help in the ultimate success or failure of our efforts. Because Clemente School is involve with a community-based after school program, we might organize a camera club to photograph or videotape our successful energy saving efforts and we might highlight our poster designs with the dollars and energy saved.

Having discussed energy conservation proposals which can be initiated at Clemente involving little or no cost, it is time to turn our attention to areas of building design. At the present, Clemente School is eighteen years old, having been dedicated in 1977. The physical, electrical and mechanical components of our school are at least eighteen years old and the technology or fuel efficiencies of these components can not possibly compare with today's improvements. We might consider retrofitting our electrical ballasts and fluorescent bulbs with

T-8 lighting systems. These fluorescent tubes are smaller in diameter then the older tubes and the electronic ballasts would replace the old magnetic ballasts. In a standard four tube, two ballast fixture (which is used in our classrooms), the old tubes and ballast consume approximately 185 watts. These can be replaced with four T-8 tubes and one electronic ballast consuming approximately 106 watts. This will save approximately 79 watts per fixture. Since Clemente has hundreds of fixtures, the savings would be substantial. T-8's deliver the same amount of light as the older fluorescent tubes they replace. Although the initial cost of installation would be additional, this would be quickly offset by the energy savings cost and the longer life of the ballast. Additionally, it would be wise to investigate rebate programs which are available from our local utility, the United Illuminating Company. These rebates could substantially reduce the initial cost of replacement equipment, making the option to convert all the more enticing.

As for windows, windows lose heat approximately ten times as fast per square foot as do walls or roofs. Even a moderate window area can account for forty percent of the total heating bill. One of the ways to minimize heating efficiency is to minimize this avenue of heat loss. Storm windows, insulated glass (thermopane), or some other method of double glazing is highly recommended. This one step will cut the heat loss through the window in half. Even with double glazing though, windows will still pour out heat at night or on overcast days when there is no compensating solar heat gain. Heavy curtains drawn at night can go a long way towards solving this problem.

Air infiltration can account for energy loss as well. Infiltration means the actual flow of warm air out and cool air in during heating months and the juxtaposition during air conditioning seasons. This leakage can be around windows and doors or simply from opening and closing doors. Infiltration can represent anywhere from 10 to 40 percent of total heating/ cooling loss. However, there are several ways to moderately control this problem. Cracks around windows should be caulked yearly. Weather striping helps seal openings around doors and windows. A double door at all entry/exit areas would help prevent large masses of cold/warm air from coming in when people enter or leave. These infiltration precautions could help to lower our heating/cooling costs significantly.

It is important to recognize that all of these percentages vary according to specific building designs, traffic patterns, and types of mechanical systems employed at Clemente. However, by utilizing these suggestions constructively, our heating and cooling costs could be substantially reduced. Most importantly, our savings, both in terms of energy and dollars will take a united team effort. I remind everyone of the single hot water faucet in the teachers' faculty lounge which became the basis for this entire project and the substantial loss of energy and dollars to our entire community. The savings are real both for us today and the people of tomorrow.

V. Student Home Assessment

Having actively participated in our Clemente energy conservation program, our students will have learned ways to substantially reduce energy costs in their homes and to help their parents save money too. Householders and landlords alike can benefit from efficient insulation, replacement of broken doors and windows, and using conservative limits on thermostats. People today are accustomed to room temperatures above 68 F but somewhat lower temperatures are equally healthy. Above all, everyone who regulates the thermostat should understand the limits agreed upon in the home and they should understand the benefits of energy savings in dollars and cents. Individuals should turn off unnecessary lighting, stop preheating ovens, use cooler water for washing and bathing, use dishwashers and stoves when filled to capacity and keep refrigerators closed as often as possible.

Students should be encouraged to research large scale conservation projects on their own. They should realize that their own behavior at home can have a major impact on local conservation. For example, students could research how much water they use when they take a shower by placing a bucket under the shower and letting it run until the bucket is full to the one gallon mark. Most students will find that it takes only 20 seconds for a gallon of water to fill the bucket. Then they could time their showers each morning and calculate how much water is being used by themselves and by their family members(in a day—a week—a month—a year). The number of gallons will produce staggering results. Related experiences can be tabulated by the number of toilet flushes in similar time periods. About five gallons of water is used for every flush. Challenge students to brainstorm ways of conserving water both at home and at school.

In New Haven, residents use between 55 and 75 gallons of water each day. of these totals, 40% is used for toilet purposes, 30% is used in the bathroom sink and shower areas, 15% is used for laundry, 10% is used in the kitchen, and 5% is used outside. That results in approximately 97% of all our water is used to transport waste and roughly 3% is used for drinking and cooking. These figures can present a clearer picture of our water needs and perhaps define solutions to maximizing our water usage, once again saving money and energy.

VI. Conclusion

This curriculum unit has been designed to remind us that the resources that we take for granted will not always be there, and that it is up to us not only to do our best to preserve them, but to find new ways to save energy in our homes, our schools, and our places of employment. This unit has given our students many opportunities to solve problems, to monitor results, to chart and graph information, and to engage in critical thinking processes. Students have been taught interdisciplinary skills, got involved in cooperative learning activities, and actively engaged in hands-on projects. We have been able to help students understand real world applications of academic skills, especially in math and science. We've also been able to provide opportunities to save energy and money, and to provide opportunities for service to the school and to the community. Most of all, we have achieved individual personal satisfaction which hopefully will have positive, long-term effects.

VII. Lesson Plans

This year the ideas that I present for lesson plans will involve several "hands-on" activities because its the experimentation processes which drive this unit. This is not to suggest that the technical information and the organizational skills are less important but rather that kids tend to remember concepts more easily that are associated with explorations and first-handed experiences. Subsequently, a wide variety of ideas and projects will be presented, allowing fellow educators the flexibility to pick and choose plans that are best for their group and their level of learning.

Lesson Plan #1

Build a model of the physical plant of your school building. Be sure to identify areas involving physical, electrical, and mechanical components, entrance and exit doorways, windows, skylights, and loading docks. This model will become very useful when assigning areas to be monitored for your water, electrical and air infiltration teams as well as public relation events when groups such as the local media, the local board of education, or P.T.A. groups are invited to meetings that discuss the value and the savings of real tax dollars as an outgrowth of the unit’s success. Areas where significant savings are realized can be highlighted.

Lesson Plan #2

As has been discussed in the main body of this unit, daily monitoring of electricity in individual classrooms and common areas as well as checking all water fixtures throughout the complex represents the heart of our conservation program. Teamwork with our classmates with these concerns as well as working with the head building engineer and our custodial staff will help to closely monitor our heating and cooling systems. While our plans involve these activities, data will be charted and graphed daily, with results tabulated on a quarterly and annual basis. Previous and recent billings from the utility companies will determine the effective progress of our program.

Lesson Plan #3

Certainly, familiarity with measurement concepts of volume, cubic feet, gallon, and kilowatt needs to be discussed as they relate to energy expenditures and cost. To return to the hot water faucet situation in our faculty lounge, our students needed to understand quarts and gallons to properly measure the water that we were losing daily. Using the constant flow theory, they were able to calculate the approximate number of gallons, assuming that the condition was allowed to persist, in a year. Having called a water company representative, we were able to calculate the water cost based on cubic feet assessments. Because it was a hot water faucet, the gas company gave us their fee to heat that hot water and the sewer control authority responded with their charges to transport the water away. All in all, the students learned a very valuable lesson at the expense of the local taxpayer.

Lesson Plan #4

Guest speakers from The United Illuminating Company, the Southern Connecticut Gas Company, the Regional Water Authority and the Sewage Disposal Center are available to discuss their local histories, to show slides highlighting their services to the community, and to arrange group tours through certain areas of their facilities. Classrooms should avail themselves of these opportunities.

Lesson Plan #5

Research reports allow students to work independently and then to share their information cooperatively in a variety of ways. Topics suggested might include: 1) solutions to an energy crisis; 2) how a family can reduce or conserve energy at home; 3) what they would do if electricity was unavailable for a week, etc.

VIII. Appendix

A. Teacher Bibliography

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Exploring the Water World, The Regional Water Authority Science Curriculum, New Haven, 1991.

Science Energy Workshop, American Nuclear Society, La Grange Park, IL 60525

Wilson, Carol. Saving Through Energy Management. Wilson Educational Services, Inc. Wallingford, Ct. 1995.

B. Student Bibliography

“How To Understand Your Utility Bill” Department of Energy. Office of Public Affairs, Washington D.C. 20585

“Wilsonews”, Wilson Educational Services. Wallingford, CT 06492

“You and Your Electric Company”, Edison Electric Institute, Washington, D.C. 20036

C. National Energy Education Resource Organizations

1. (Attached) Diagram 1 and 2.(Available in Print Form)

D. Supplementary Lesson Plan Questionnaires and Activities.

1. (Attached) Diagram #3—Water Conservation

2. (Attached) Diagram #4—Energy Crunch

3. (Attached) Diagram #5—Sample Energy Audit

4. (Attached) Diagram #6—Consumer Problems

5. (Attached) Diagram #7—Energy Saver Award

(Diagrams #s 4 and 7 Available in Print Form)

Energy Education Resources from Other Organizations
(figure available in print form)

A Water Conservation Problem

Name

Date

1. Estimate on the average how long you take a shower.
2. Estimate about how many times a year you shower.
3. Estimate the amount of time you spend each year in the shower.
4. With your group, use showerhead A, the traditional showerhead, and determine how much water flows through it in one minute. Try it twice and use the average.
5. With your group, use showerhead B, the water saving showerhead, and determine how much water flows through it in one minute. Try it twice and use the average.
6. How much water would you use in a year using the traditional showerhead?
7. How much water would you use in a year using the water saving showerhead?
8. Assuming there is a difference, how much water would you save using the water saving showerhead? What is the percent of savings?

Energy Crunch

(figure available in print form)

SAMPLE ENERGY AUDIT ACTIVITIES

Activity 1

Some classrooms are over lighted. State standards recommend 50 foot/candles of illumination at desk height for classrooms. Even on gloomy days, the desks near the windows receive over 100 foot/candles from natural lighting. We will calculate the energy and dollars which could be saved if the lights along the windows were never turned on during the daytime.

Work with a partner to determine the following information and fill in the blanks.

A. Number of bulbs to be kept off per room.
B. Wattage of each bulb.
C. Hours per day each bulb will be kept off.
D. Days per year bulb will be kept off.
E. Number of classrooms which can keep the same bulbs off.
Check your numbers with the rest of the teams. Make any necessary changes above.
F. Calculate the energy to be saved in one classroom by leaving these bulbs off.
(A) x (B) x (C) x (D) = (F) Watt-hours/year
Convert the Watt-hours to kilowatt-hours/year
(F) 1000 = (G) kilowatt-hours/year
Calculate how many dollars this action would save
(G) x (cost/kwh) = saved per year
Calculate the savings for all the classrooms
(H) x (E) =

Determine if it is worth doing, you must compare the savings with the cost to do this action. Since it costs nothing to leave the bulbs off, it is certainly worth doing. How would you accomplish this action in your school?

Consumer Problems

1. A building has 1,000 light fixtures, each with two 40 watt tubes. The lights are used 5 days a week, every week of the year for about 8 hours a day. How many kilowatt hours/year can be saved by replacing the existing tubes with 34 watt bulbs? At $.08/Kwh, how many dollars/year would be saved?
2. The Brook's will replace five sockets and four switches in their home. The sockets cost $2.37 each and the circuits cost $4.19 each. How much will these repairs cost?
3. The June bill at Mr. Fitzpatrick's house was $98.26 which was twice as much as the May bill. The July electric bill was $40.00 higher than the May bill. What was the total cost for these three months of electricity?
4. Ms. Parks has an art kiln that uses 8.50 kilowatt hours of electricity in 30 minutes. How much electricity is used in five hours?
5. If Clemente school purchased 1,000 Kwh of electricity at $.10/Kwh and 1,000 ccf of natural gas at $.75/ccf, what would the total cost?

Energy Saver Award

(figure available in print form)