An Assessment of Active and Project Based Learning in Energy Conservation Education for Non-Technical Students

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Abstract

A 3-credit general education course on "Energy Conservation and Environmental Protection" was developed for mostly non-science/engineering students. The objective of the course is to expose students to energy efficiency in day-to-day life to save both money and energy thereby protecting the environment. This course provides students with the necessary knowledge and information on the main operating principles of household devices/appliances enabling the appropriate selection of energy efficient, cost effective, and environmentally responsible choices. The course relies on active learning components to enhance the cognition of the fundamental concepts of heat transfer, principles of energy conversion, and thermodynamics. The course successfully generated interest in the student population as reflected in the enrollment increasing from 40 students in the first semester to 600 plus students per semester in the third year of offering.

In this class, students perform four individual projects (active learning) in lieu of formal homework and one group project with four members in each team. The purpose of these projects is to reinforce the concepts with hands on activities performed outside the classroom. Group projects are selected by the group members from a number of choices: selection of most energy efficient and economical appliances, lighting and appliance energy savings, automobile savings, hot water savings, or dormitory energy conservation. The students learn the subject matter through individual hands on projects and peer-to-peer interaction within group projects.

The paper presents examples of the projects and discusses the impact of individual and group projects on students' learning. Students' feedback on learning effectiveness through projects will also be discussed. The paper will also present the qualitative impact of projects on students' interest in the subject to promote life long learning in this area.

Introduction

In the fall of 2001, the Department of Energy and Geo-Environmental Engineering initiated a drive to educate more students in Energy related subjects outside our majors. A 3-credit general education course on "Energy Conservation and Environmental

Protection" (EGEE 102) was developed and offered primarily for non-science/engineering students. The objective of the course is to expose students to energy efficiency in day-to-day life to save money and energy thereby protecting the environment. Education such as this is very important for all college students to create environmentally responsible citizens of this Global Village.

This course was first offered in the fall of 2001 in two sections with a combined enrollment of 69 students. The enrollment for spring 2004 is 660 students within five sections. The methodology used for teaching and learning has been discussed previously[1]. The student population in this class represents 87 different academic majors primarily from the Colleges of Arts, Liberal Arts, Business Administration, and Communications.

Teaching methodology

The course utilizes multimedia materials such as video clips (followed by class discussion), crossword puzzles to reinforce the terminology, and problem solving. These group activities have promoted collaborative and joint intellectual learning atmosphere as opposed to traditional lecturing environment. This course entails various simple group-activities in class to reinforce the information presented through formal lectures and reactivate the students' attention [(2)]. The group activities included conducting a set of experiments and/or gathering and analyzing data, presenting the observations in the form of a written report. These activities can also be in-class demonstrations.

In addition to these in-class activities, students are required to complete four individual projects (activities) in lieu of formal homework and a group project. The purpose of these projects is to reinforce the concepts with hands-on activities performed outside the classroom. The projects embody the key rationale for active learning, namely that "students learn more and better when they explore a topic rather than they watch and listen to a teacher" [(3)]. The students in groups of four complete a self-selected group project involving either: the selection of most energy efficient and economical appliances, lighting and appliance energy savings, automobile savings, hot water savings, or dormitory energy conservation. The students learned the subject matter through individual hands-on projects and peer-to-peer interaction within group projects.

Objective of this work

The main objective this work is to study the effect of individual projects and group projects on students' learning. The effectiveness of learning was evaluated based on the students' performance and experiences. The qualitative impact of the projects on students' interest in the subject was also studied.

Brief Description and examples of individual projects:

Project 1- Effect of acidity on germination of seeds

The objective of this project was to gain hands-on understanding of the effect of acid rain on sprouting of plant seeds. Students are given 50 bean seeds each, to perform this project. They prepare acid solutions at home using lemon juice or vinegar. They immerse 10 seeds in each acidic solutions and tap water. Students observe the sprouting pattern for about a week and summarize their result.

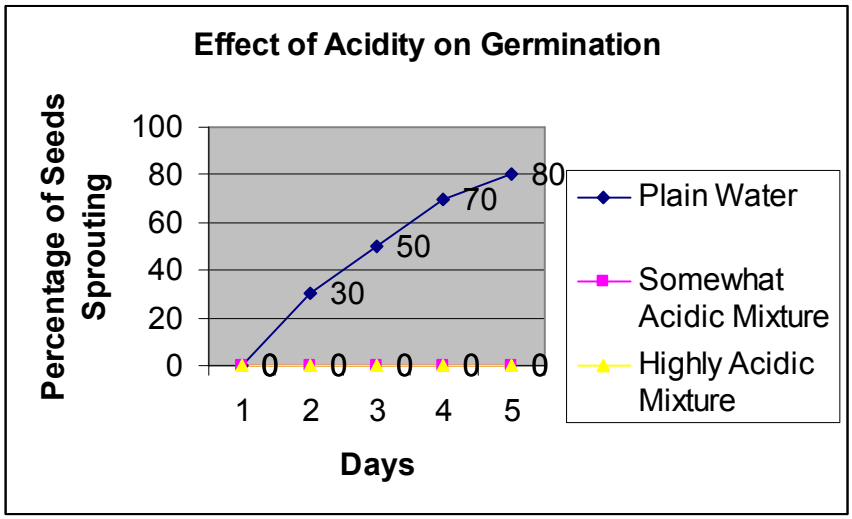
An example of a student report is reproduced below:

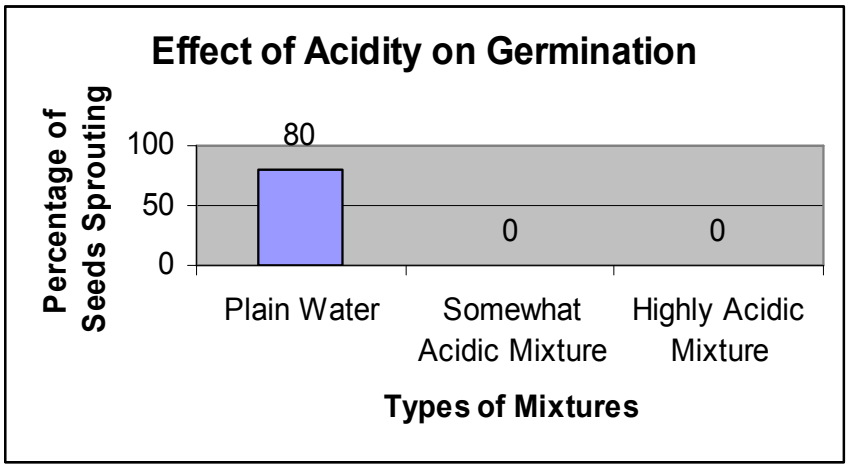
Effect of Acidity on Germination

Procedure:

I began the experiment by gathering all the materials needed. This included 3 cereal bowls, vinegar, and Mung beans. After that I put 10 seeds in each of the 3 bowls, and then poured a half of a cup of water into one of them, adding just enough to dip all the seeds. For the other 2 bowls I made two different mixtures, one somewhat acidic and one highly acidic. In order to make the somewhat acidic mixture I added 2 teaspoons of vinegar to a half of a cup of water, mixed it together, and poured it into the bowl, adding just enough to dip all the seeds. To make the highly acidic mixture I added 5 teaspoons of vinegar to a half of a cup of water, mixed it together, and poured it into the remaining bowl, adding just enough to dip all the seeds. Then, for a week I examined each bowl to see how many seeds had germinated, and recorded the results. While doing so I made sure that if any of the water, or acid mixtures had evaporated I added more in order to immerse the seeds again.

Graphs:





General Observations:

While looking at the 3 different mixtures; plain water, somewhat acidic, and highly acidic, I can obviously see that only the seeds in the plain water sprouted. Also the color of the plain water was no longer clear and it became a light shade of yellowish-brown and was a little foggy. Also there was a yellow

ring of slime around the level of the water on the inside of the bowl with just plain water. However, the other 2 bowls (somewhat acidic and highly acidic) had no change in water color, and there was no slime ring.

Conclusion:

From this experiment I have learned that acid (vinegar in this case) at any level has an effect on how Mung seeds will grow. Just by adding 2 teaspoons of vinegar to a half of a cup of water prevented any of the 10 seeds from growing. Seeing how well the seeds in plain water grew further supports my conclusion, because after only 2 days of being immersed in the water they began to sprout.

Thoughts on the Effect of Acid Rain on Vegetation:

I believe that acid rain has a lot negative effects on vegetation. Relating to the experiment that I performed, I was able to see how much vegetation can be effected by acid. The acid in the bowls preventing the sprouting of the Mung beans can be related on a larger scale to acid rain falling on a crop, thus the crop would have a very tough time growing under such conditions. I believe that we need to do something about the problem of acid rain, before no vegetation is able to flourish.

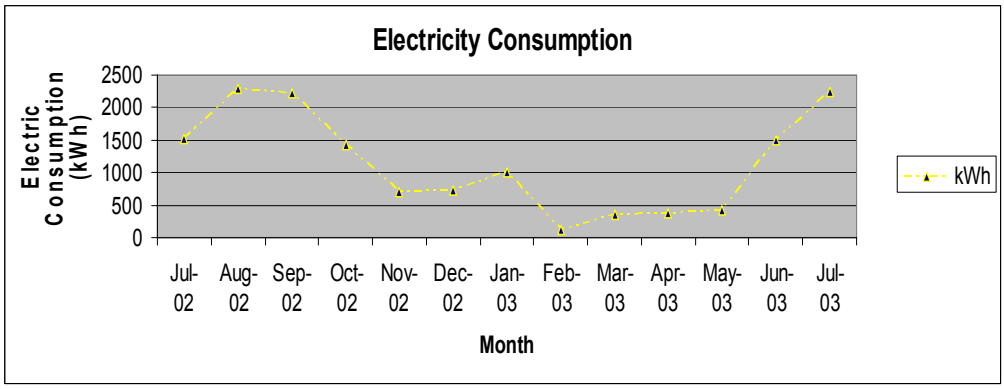
Project 2 – Home Energy Usage Analysis

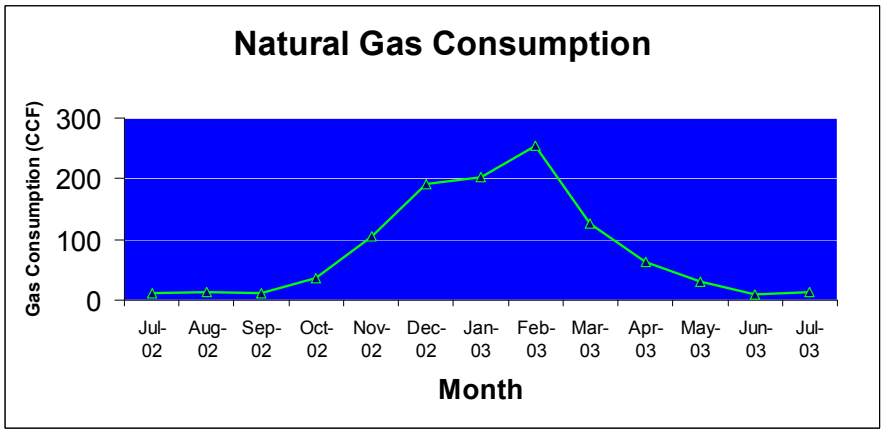
The objective of this activity is to analyze the home energy usage pattern. Students are asked to collect one year (12 months) of utility bills for all the home energy sources they use. Students analyze the seasonal variations in the total energy and the type of fuel used and they determine the relative percentages of energy sources and the relative costs of each. They also determine the environmental impact of their energy use.

An example of a student report is reproduced below:

Energy Usage Analysis

	Natural Gas		*Electricity*	
Month	*CCF*	*Cost*	*kWh*	*Cost*
Jul-02	*12*	*$18.53*	*1524*	*142.3*
Aug-02	*13*	*$19.27*	*2292*	*211.14*
Sep-02	*12*	*$18.61*	*2208*	*203.94*
Oct-02	*37*	*$41.70*	*1416*	*133.13*
Nov-02	*106*	*$104.94*	*708*	*69.81*
Dec-02	*192*	*$186.93*	*720*	*70.88*
Jan-03	*202*	*$212.41*	*1008*	*96.52*
Feb-03	*255*	*$267.86*	*120*	*17.13*
Mar-03	*127*	*$137.37*	*360*	*38.45*
Apr-03	*63*	*$79.18*	*372*	*39.52*
May-03	*31*	*$44.46*	*432*	*44.85*
Jun-03	*10*	*$21.62*	*1486*	*139.28*
Jul-03	*13*	*$24.64*	*2244*	*205.88*
Total	*1073*	*$1,177.52*	*14890*	*$1,412.83*
Total BTU's	*107,300,000.00*		*50,804,680.00*	





Total Btu's of Natural Gas consumed
*=1,073*100,000*
=107,300,000

Cost per one million Btu's of Natural Gas
=$1,177.52/107.3
= $10.97

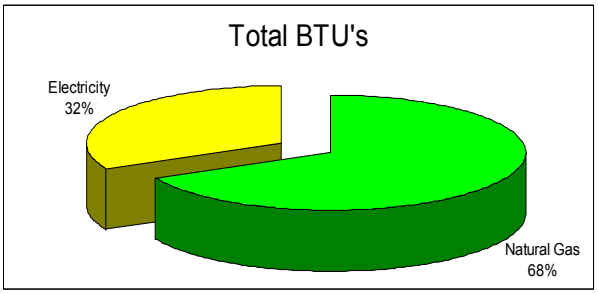
Total Energy consumption per year MMBtu
=107.3+50.80468
=158.10468

Average cost($) for million Btu's of energy used
=$2,590.35/158.10468
=$16.38

Total Btu's of Electricity consumed
*=3,412*14,890*
=50,804,680

Cost per one million Btu's of Electricity
=$1,412.83/50.80458
= $27.81

Total cost of 158.10468 MMBtus
=$1,177.52+1,412.83
=$2,590.35



Clearly, my family uses more Btu's of Natural Gas than electricity. Though our electricity bills are always higher, the calorific value of Natural Gas is far higher. I guess in a way, the fact that we use more Natural Gas is kind of a good thing because it has less environmental effects as compared to electricity. Electricity generation requires the consumption of coal and this expenditure of coal is harmful to the environment in terms of the pollutants it emits when burned. Aside from financial costs to acquire this energy form, society also pays another cost. Acid rain and reduction in visibility are just a few negatives that come from the consumption of electricity. Natural Gas is a cleaner burning, safe gas to use. The real problem is that electricity can be made from renewable energy sources such as hydroelectric dams and solar panels; Natural Gas is an exhaustible, non-renewable energy source that is being depleted at a large rate.

Fuel	***Cost/MMBtus***
Electricity	*$27.81*
Fuel Oil	*$8.19*
Natural Gas	*$10.97*

Total Average Monthly Energy Bill
=(1,177.52+1,412.83)/12
=$215.86

What is the location (address) that you analyzed? *I analyzed my home in Pittsburgh.*
Which company provided the electricity, gas and oil? *Duquesne Light Company is my family's electricity provider and Peoples Gas Company provides our home with Natural Gas.*
Which is the fuel you used for cooking and water heating? *Our stove and water heater are both supplied by natural gas.*
Do you have air conditioning at home? If so, is it a room air conditioner or a central air conditioner? *Yes, I have central air conditioning.*
Which fuel did you use for home heating? *Our home is heated with Natural Gas.*
This exercise helped me understand utility bills in a few ways. First, they are expensive, so it is best to have the most efficient ways of limiting energy consumption. But more importantly, after going through my family's bills, I have realized that quite simply, we are being too careless with our electricity and natural gas usage. I will be more apt to turn of lights, TV's, computers, etc., when I am not using them because I now realize how much money and energy is being wasted for no good. I will also be able to enlighten my siblings to help out with the bills by being more cautious with how they use utilities. If they are not using things, I will try to remind them to shut them off. By being more conscientious, this will not only help my parents out by lowering the cost of the utility bills, but it will also be more helpful to the environment. If I can just do a few things, maybe a couple others, such as my family, will also take the initiative to be more energy efficient. After all, it will not save the world, but it will make just a little difference. However, a little difference is better than nothing!

Project 3 – The Effect of Insulation on Home Heating Costs

This project consists of three parts. Students perform the experiment using an interactive computer-based multimedia simulation. Details of this project can be seen in elsewhere[1].

Part 1: To determine the most effective type of insulation (R-Values).

This was accomplished by completing a virtual experiment with several boxes with different insulation materials all heated by incandescent bulbs inside the box. The internal box temperature is recoded by the student (actually read off the virtual thermometers), and graphed as a function of time; permitting them to elucidate the significance of R-values. The R-value of a composite wall is also calculated.

Part 2: To determine the cost effectiveness of various insulation materials.

This objective is accomplished by obtaining current purchase price of five different insulation materials used in the simulation, calculating the heat loss using the heat conduction equation and plotting a chart of reducing heat loss with increasing insulation (costs) and recommending the most cost effective insulation. Current costs of the insulation materials are student obtained by visiting a home improvement store.

Part 3: To extend and apply the knowledge gained in Parts 1 and 2 by selecting a location, house size, type (single level or bi-level), number and type of windows, and the type of fuel used. Thus, enabling the student (via the simulation to study the effect of various parameters) to calculate the payback period.

Project 4 – The main objective of this project is to relate the material that was discussed in class to the "real world". This project involves going around the house (inside and outside) and conducting an energy audit. This project is also aimed at identifying various energy components and obtaining specifications for those materials.

An example of a student report is reproduced below:

Student
Home Energy Audit
December 1, 2003

OUTSIDE OF YOUR RESIDENCE
1. Are there any cracks or openings in the outer shell of the structure? Yes____ No_X__
List the places where there are cracks or openings:
2. What is the condition of the caulking where two different kinds of building materials meet?
Good ____X_____ Fair _____ Poor _____ or missing:
3. What is the condition of the caulking where windows and door fit into the structure?
Good ____X_____ Fair _____ Poor _____
List the places where it is poor or missing:
4. Is there some type of insulating material placed in the openings where pipes, wires, hoses, etc. go into the structure? Yes ____X_____ No_____
List the places where there is none:
5. Do you have a swimming pool? Yes _____ No _____X_____
Is it heated? Yes _____ No_____
How is it heated: _____
Is it covered at night? Yes _____ No _____
What type of cover is used: _____

6. Explain any passive solar methods that your residence uses to help heating and cooling costs. (For example, any south facing windows or trees etc.): Some south-facing windows; thick drapes on bedroom windows;

INSIDE YOUR RESIDENCE
1. Windows and doors:
a. Are the windows and doors caulked and weather-stripped? Yes _X__No___
List the locations of the windows and doors that are not:
b. What is the condition of the caulk and weather stripping?
Good ____X_____ Fair_____ Poor _____
List the location of where the caulk and/or weather stripping is poor or missing:
c. Describe the type of windows you have: __Double hung thermopane_____
d. Do you have and use storm windows and doors? Yes _____ No, since the windows are double insulated and the doors are insulated _____
e. For each window, list the type of interior covering you have for it (i.e. curtain, drape, blind, etc.).
Bedrooms: pull shades and fabric curtains; Living room: sheer curtains;

Family room: fabric drapes; Dining room: sheer curtains; Kitchen: no covering;
Bathrooms: pull shades

2. Fireplace or wood burning stove:
a. Do you have a fireplace or wood-burning stove? Yes _____X____ No ____
b. What kind and type is it? Standard masonry
3. Heating System:
a. What type of heating system do you have Heat Pump
b. Are the heating vents clean? Yes ____X____ No_____
c. Does the thermostat work properly? Yes _____X____ No _____
d. When was the last time the filters were replaced, if you have them:
2 years ago, but they are high-performance filters
e. If there is duck work for the system, are there any leaks or missing ducts?
Yes _____ No___X_____
If yes, where
Is the duct system insulated? Yes X, fiberglass ducts No_____
f. When was the last time the heating system was cleaned, checked, etc?
Spring, for the cooling season
4. Water heating system:
a. What type of water heating system do you have:
Electric hot water
b. Is it insulated? Yes ___X_____ No _____
c. Are the pipes insulated? Yes ____X_____ No _____
d. What is the temperature setting: 130 degrees F
5. Basement:
Are there any openings around the foundation walls or openings going under the structure?
Yes _____ No___X_____
List the location of any openings:
b. Is the basement ceiling insulated? Yes ____X_____ No _____
What type of insulation is it? Fiberglass
6. Attic:
a. Is there insulation in the attic? Yes ___X____ No _____
What type is it? Fiberglass
What is the thickness of the insulation? 18 inches
What condition is it in: good condition
b. Are there any attic fans? Yes _____ No fans, but ventilation to support the size of the attic
How many are there and where are they:

SUGGEST WAYS TO CONSERVE ENERGY IN THE RESIDENCE
From your findings, and instructor's help, list the ways in which you could conserve energy within the structure.

- *Install a geothermal heat pump*

  Especially since my dad used to work with a company that manufactured insulation, he is conscientious about good insulation (almost to the point of obsession). He finished the basement himself, and replaced the insulation in the attic; he even found a way to block the vents near the fireplace that constantly let in cold air. The house doesn't lose much heat through the walls, relatively speaking—but even so, living in Central Pennsylvania means that the cost of installing a geothermal heat pump would quickly be made up in energy savings.

- *Remember to check and clean ducts for the heating season*

  As mentioned before, my father runs a tight ship—but since the ducts haven't been checked yet this year, this important step should be reiterated.

- *Set the water heater to a lower temperature*

130 degrees F is even higher than the 120 degrees standard mentioned in class. Since water heaters comprise the third biggest energy consumption in the home, making this system efficient would greatly help conserve energy. While our dishwasher is at least ten years old and probably could not heat water from 100 degrees on its own, it would make sense to set the water heater down to 120 degrees. In that line of reasoning, it would even make sense to buy a new dishwasher, set the water heater to 100 degrees, and save even more on water heating costs.

- *Add thermal drapes in bedrooms*
  All bedrooms have curtains or drapes with which to block summer sun, but these may not have sufficient heat-retaining capacity. Without compromising my mom's downstairs decorating scheme, the thermal drapes in the bedrooms would help keep the upstairs warmer at night when people are sleeping in the bedrooms.

- *Replace shower heads with low-flow models*
  Since I am no longer living at home, this may not be such a large concern. New shower heads, however, could still further decrease the family's water usage, thus conserving money and energy.

- *Finish storage area in basement*
  While most of our basement is finished with drywall and insulation, there is a large storage area that could represent a drain on heating resources for the house. The ceiling is insulated, and while the unfinished space is ideal for the family workbench and the cats' litter area, further insulation could help cut down more on energy costs.

- *Replace the basement refrigerator with a newer, more energy-efficient model*
  My family uses two refrigerators; the younger one is about ten years old, but the older one has been around for as long as I can remember. Since it's kept in the basement, it doesn't need to use quite as much energy to keep cool—but newer models' improved efficiency would make one a good investment. Even our 'new' one could stand to be replaced, but the old refrigerator is the bigger drain on energy.

Group Project

This final group project has to be done in groups of 4. Each group can select a project from the following four and complete it in consultation with the instructor or Teaching Assistant.

1. Selection of Appliances

Instructions: Experience has shown that the most cost-effective and sensible approach to today's energy situation is energy conservation. Each of us must realize that we cannot continue consuming energy at the present rate. We must look for ways to decrease our use of energy. Selecting the most efficient appliance is most important for energy conservation.

This involves selecting an energy efficient device from the following: Car, Home heating furnace, Air conditioner, Refrigerator, Water Heater, Clothes washer and dryer. After you choose the device you need to write down the required features of the device. For example, a water heater for a family of four; gas fired or electric depending on the energy form available size etc.
Go to a store and shop for four different "Makes" with similar specifications. Compare the life cycle analysis involving the appliance cost and operating costs over the life time

of the device and calculate the pay back period. Prepare a report comparing the features of the four makes, appliance costs and energy costs, the energy and cost savings over their lifetime. Also calculate the environmental benefit of this personal choice by converting the gallons of gas or kWh of electricity saved into amount of pollutants avoided.

2. Lighting and Appliance Energy Savings

The purpose of this project is to discover ways to decrease the consumption of energy when lighting and using appliances in our homes.

Activity 1: How Many Watts for Seeing?

The purpose of this part is to discover how much lighting wattage is necessary for activities such as sewing, reading, and other daily routines. The assumption behind this experiment is that if we used light bulbs with appropriate wattage, we could save the energy wasted on unnecessary lighting. You will need a lamp next to a comfortable chair in a dark room, several bulbs with different wattages (for example, 25 watts, 40 watts, 60 watts, 75 watts, 100 watts); a light meter, a book to read, something to write with, or a sewing project; a watch. Summarize your observations in a paragraph or two.

Activity 2: Classroom Lighting

The purpose of this activity is to determine the appropriate lighting conditions for a classroom. To complete this activity you'll need a light meter and an empty classroom with adjustable lighting. Close the shades and adjust the classroom lighting to the most comfortable level for the following scenarios: Reading a book, watching a lecture and taking notes, viewing slides, and viewing the chalkboard. Using the light meter record the illumination on the student desks for each condition. For each condition, also estimate the energy usage by counting the number of light bulbs illuminated and the dimmer switch setting. Assume that all fluorescent bulbs operate at 40 W. Multiply 40W by the dimmer switch setting to find the wattage in those cases. For instance, if the dimmer switch is down by about 1/4, the wattage is 40W*(3/4) = 30W. Estimate the operating costs over 100 hours at 10 cents per kWh. Summarize your findings and their implications in a paragraph or two.

3. Automobile Savings

There are more than 213 million registered automobiles in the United States. A typical car, with an average fuel economy of about 19.4 miles per gallon, travels about 12,000 miles each year and uses over 600 gallons of gasoline. This means that private automobiles consume some 120 billion gallons of gasoline each year. The importance of gasoline conservation by individual drivers cannot be overemphasized. The purpose of these activities is to discover some important ways to decrease energy consumption in transportation.

Activity 1: Comparing Gas Mileage

The purpose of this activity is to compare the fuel efficiencies of automobiles on the market today. Visit a car sales lot. Choose 3 types of cars, for example, examine large luxury cars, medium size family station wagons, and small sports cars. Other types might include mini-vans, full-size trucks, or small-size trucks. Visit several car sale lots and

collect information on several makes and models within your 3vehicle choices. Record all data. Create a better chart for organizing your data if necessary. Which car is most energy-efficient? What other factors would you consider in buying a car? Which car would you like to buy if you could, and why?

Activity 2: Fuel Consumption per Passenger Mile

The purpose of this activity is to compare alternative types of transportation and how much fuel each consumes. You will need a telephone and the supplied chart. Calculate the gas (or energy) used per person if he/she goes the same distance by bus, car, motorcycle, airplane, bicycle, and other forms of transportation. To do this, call your local public service bus office or school bus garage and ask how big the average bus tank is, how many people can ride on a full bus, and the average gas mileage of a bus? Call the maintenance division at an airport to get similar information for an airplane. Call shops or use your own information sources to get data on cars, motorcycles, and other vehicles. Record all the data in the chart.

Which form of transportation is most energy-efficient? What other factors must you consider in choosing transportation? Which form of transportation do you choose most often, and why?

Activity 3: Planning Your Trips

The purpose of this activity is to determine if planning a route helps save energy. You will below. Choose 5 points of destination on a map. The points could be stores or street corners or homes. Then ask your 4 friends separately to visit the 5 destinations. Ask them to record how many miles they drive between spots. Ask two of them to plan their routes, using maps. Don't ask the other two to do anything special. Collect the charts after they have completed the route

Which person traveled the fewest miles in completing the course? Why? Was **it** one of the drivers who planned their routes? What percentage of the fuel costs will be saved by an effective planning of the trip?

4. Hot Water Savings

Each of us must realize that we cannot continue consuming energy at the present rate. We must look for ways to decrease our use of energy. Perhaps more than any other areas of energy conservation, our daily routine habits (e g., the length of time we spend in the shower) affect energy consumption in the amount of hot water we use. In these activities, you will explore ways to decrease hot water consumption by changing habits and being informed consumers.

Activity 1: Hot Water Loss from Leaking Faucets

The purpose of this activity is to determine how much water is wasted by leaking faucets. Calculate how much water would be wasted in a day, a month, and a year for each water drop situation. What is the energy wasted (Btus) in heating the wasted water? Assume that water is heated from 60F to 120 F in the water heater.

Activity 2: Washing Clothes in Cold vs. Hot Water

The purpose of this activity is to compare clothes cleaned in hot and cold water. The assumption is that if more clothes can be cleaned in cold water, then energy used to heat washing water can be conserved. Compare which stains are cleaned in each load. What can you conclude about how well particular stains come out in hot or cold water? Is hot water necessary for cleaning all, some, or none of the stains?

Activity 3: Taking Baths vs. Showers

The purpose of this activity is to compare the amount of water used taking a bath with that used taking a shower. Design an experiment to complete the activity and describe the procedure used. What can you conclude about the amount of water and energy (Btus) you use in bathing/showering?

5. Dormitory Energy Conservation

We must look for ways to decrease our use of energy. University, faced with rising energy costs and mindful of the tuition increases, must find ways to use energy more effectively. The purpose of these activities is to discover how the University is billed for energy use, how large these bills can be, and how they can be reduced. Here is an example of a project submitted by a student.

An example of a student report is reproduced below:

Activity 1 - Bills and University Energy Management

Q: How is the university billed for electricity?
A: The University gets billed monthly from Allegheny power by:
1) Total kWh consumed @ $0.00277 per kilowatt-hour.
2) Averaged weekly demand by month kVA @ First 10,000 kilovolt-amperes $0.91 per kilovolt-ampere and additional kilovolt-amperes@ $0.90 per kilovolt-ampere.

"The billing demand for any month shall be the average of the weekly demands established during the calendar weeks ending within the billing month. The demand for a week shall be the maximum simultaneous fifteen-minute kilovolt-ampere demand but not less than 50 percent of the highest weekly demand of the month (www.alleghanypower.com)."
Also, in an agreement, Pennsylvania State University agrees not produce any additional electricity from on campus power plants (excluding heat and steam). If they do they must sell it back to Allegheny Power on demand.
Penn State receives other sources of energy:
1) Natural Gas from Columbia Utilities and Peco.
2) Coal, propane, and fuel oil are billed on delivery.
Conclusion: Penn State uses electricity, natural gas, coal, fuel oil, and propane to meet its energy needs.

Q: Does Penn State has higher utilities in winter or spring?
A: The peak energy consumption is during the spring semester from December to April. This is probably due to the winter weather conditions and the fact that students spend most of their time indoors studying.
Source: http://energy.opp.psu.edu/engy/Consumpt/UP/UPEnergy.htm

Q: What fuel is used most to heat the dorms?
A: Coal is the main source used to the heat the dorms, but natural gas is used also. The coal is used to make steam (in the West Campus Steam Plant) where it is then sent to the dorms. Some dorms use the steam directly in room radiators. Below is a graph of coal consumption during a year: You can see that during the prime heating season, Penn State's coal consumption jumps greatly.
Source: http://energy.opp.psu.edu/engy/Consumpt/UP/UPEnergy.htm

Q: Is certain equipment operated intermittently to reduce maximum power requirements?
A: Penn State and OPP have tried unsuccessfully to reduce services during low peak times (such as night time.) It is hard to start and stop requirements (like heating and cooling) and not interfere with faculty and students activities.

Q: How is hot water for the dorms generated is it on time clock, and what happens on weekends?
A: Hot water is generated from steam produced at the West Campus Steam Plant. It is separated from the steam that uses to heat the dorms but is sent through a heat exchanger in the dorms. Since hot water storage would have to be massive (and the increase surface would contribute to added heat loss) to meet the needs of dorms and students use hot water at all time of the day or night, hot water heater runs all the time and continuously.

Q: What are ways to lower University or energy bills?
A: Current methods already being used by the university:
OPP has changed T-12 lamps with magnetic ballasts to T-8 with electronic ballasts to reduce both energy and demand.
Occupancy sensors have been installed in areas when there is no activity within the space for a set period of time, the lights turn off.
OPP has replaced almost every EXIT sign on campus with LEDs which use less energy, and last 20+ years vs. 800 hours for an incandescent lamp.
Penn State has moved over to central chilled water for air conditioning. The larger water cooled chillers can be as efficient as 0.5 kW/ton of air conditioning.
Penn State has implemented a program called Continuous Commissioning to tune-up the existing building systems, repair components that no longer function, and to optimize the sequence of operation of the HVAC (heating ventilating and air conditioning) equipment to help improve the indoor comfort of our facilities within the capabilities of the systems that were installed.
The university has entered into guaranteed energy savings contracts by using qualified Energy Services Companies (ESCOs). This tailors that all new construction projects are done in an energy efficient way, therefore helping the university conserve.
Things we could are:
Turn off lights when not necessary.
Utilize the energy star features on copiers, printers, monitors, computers, and other major appliances.
Keep refrigerators clean and free of ice buildup.
Set thermostat to control conditions 72F or less for heating, and 78F for cooling; dress appropriately.
Turn off computers in the computers labs when they are not being utilized.
Test the possibility of using occupancy sensors in the dorms rooms for heating / lighting.
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https://cms.psu.edu/section/default.asp?id=200304FAUP+++REGEE+102H001

Activity 2- Dorm Floor Energy Conservation Survey and Results

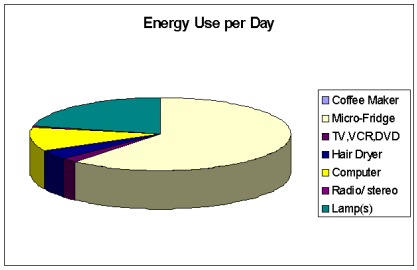
Q: What questions were asked on the survey?
A: What type of dorm do you live in? Single Double Supplemental

If you answered supplemental how many roommates do you have? _____

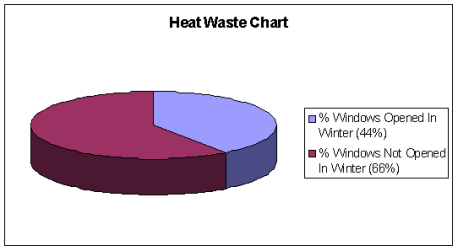
Circle the following appliances you have in your dorm room and write how many hours a day do you leave them on? (Please add the # of hours in total for each type appliance, i.e.: all roommates)
Coffee Maker _____
Micro-Fridge _____
TV, VCR, DVD etc _____

Mini Fridge _____
Hair Dryer _____
Computer _____
Radio/ stereo _____
Lamp(s) _____
Other _____
What wattage of light bulb is used in your dorm room? If multiple types please list all.
If you have a TV what is the wattage? (ex: 13inch is 65W)
Do you have to open your window in the winter because the heating in your room is too hot?
How long are your showers and how many do you take per week? Please include estimates for your roommate(s).
On average how much electricity do you use each day in just your dorm room in kWh? Take a guess.
How do you think the efficiency of dorms could be improved?

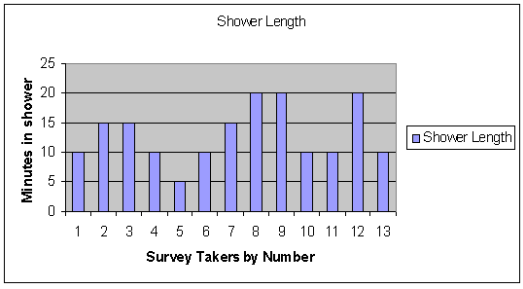
Q: Where is the energy currently being used?
A:



Q: How many windows are left open during the winter?
A:

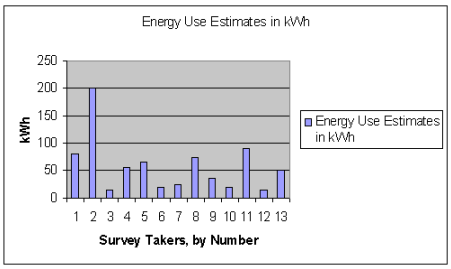


Q: How long do students usually spend in the shower?



Q: How much energy is being used?

A:



Q: How do students want to cut energy usage on the floor?
A: Several students suggested that lights could be turned off when not in use. Others suggested that heaters could be fitted with individual room controls, in order to maintain a more comfortable temperature and not need to waste energy by opening windows to equalize the heat.

Q: How much energy is wasted on the floor? (Estimate)
A: It is clear that the main waste of electricity is through lights and computers; computers use a large amount of electricity, upwards of 300kwh per machine. The micro-fridges, however, consume the largest portion of energy. It is very hard to calculate how many lights each person uses, compared to how often they are in need of lights, compared to how often roommates are using lights etc. The same goes for computers and time of usage.

The main loss of energy in dorms is through excessive heating with almost ½ of the surveyed students complaining that their rooms reach the mid to high 80's, which leads them to open their windows for relief. Once again I find it all but impossible to guess how much energy is needed to heat a whole floor of dorm rooms to 70'f compared to 85'f since I don't know anything about the structure, insulation etc, but nonetheless I'm convinced that is where the true energy is lost.

As for long showers, I found the average estimated shower length to be 13.4 minutes per shower. The showers flow very fast; however, if they were slowed to a more reasonable flow of water, and if every student was limited to 10 minute showers, considerable amounts of energy could be saved.

In conclusion I believe do to both the unwillingness of students and inefficient practices of the University millions of dollars are being wasted on wasted energy.

Activity 3- Code Requirements and Their Energy Costs

Q: What is the total wattage of the lights used in your dorm room?
A: There are a total of two fluorescent light bulbs, 20 Watts per bulb (1,250 lumens emitted per bulb).

Q: How many square feet of space do you have in your dorm room?
A: Inner Room = 180 square feet
Outer Room = 102 square feet
Total = 282 sq feet of floor space.

Q: How high are the ceilings in your dorm room?
A: The ceilings in the room are approximately 12 feet high.

Q: Are the walls painted in a light color?
A: The walls are painted a light gray.

Q: Are there windows in your room?
A: There are three single pane windows in the room.

Q: How many watts of power are used for lighting per square foot of floor space in the room?
A: Inner room = 20 Watts/180 square feet = .11 watts per square foot
Outer room = 20 Watts/102 square feet = .196 watts per square foot
In surveying 24 students, all indicated that there was adequate light to read and write in this room.

Q: Are the windows in the room ever opened, and if so, at what time of the day is this usually done?
A: Windows are opened only during the summer. During the summer, the windows are open at all times of the day because the room is not outfitted with an air conditioning unit. Windows are always closed when the heat is on.

Q: How many doors are there which lead either to the outside or to the hall?
A: There is a single door that leads to the hallway. It is usually kept closed, and there are no louvers above the door to allow extra air flow.

Q: Does the heating and cooling system vent air into the room?
A: No. There is no cooling system. The heating system used a floorboard radiator, one in the inner room and one in the outer room supply heat for the entire space.

Assessment of the Projects

The student reports presented show considerable expertise in students' ability to tackle real world energy use problems. The student ratings of the activities performed and their prior knowledge levels regarding the activities expected outcomes and approaches are presented in Tables 1 and 2. This feedback suggests that much of students' demonstrated expertise was acquired by virtue of the project assignments they encountered in EGEE 102. These findings lead us to conclude that the active learning approach recommended in contemporary education literature is effective in the context of energy conservation education [(4)]. In fall of 2003 five sections were taught and students were asked to assess the impact of the projects on their learning experience. Approximately 60% of the 525 respondents marked either "strongly agree" or "agree" that the home activities contributed to their understanding of the subject matter.

Table 1. Students' Rating of the out-of-class projects

Question	Strongly Agree	Agree	Somewhat Agree	Disagree	Strongly Disagree
The three home activities contributed significantly to your understanding of the subject matter	155	252	97	15	6
The descriptions of the instructions for the three home activities were clear	189	230	88	16	2
The Home Activities are more interesting and useful than regular homework (descriptive questions and problems)	194	234	73	20	4
Contribution from the each of the members was equal	155	191	90	43	46

What is also evident from discussions with students and the in-class environment is that there is a great deal of enthusiasm for relating knowledge to real applications that they may actually use. From Table 2 it is clear that the average (non-science and non-engineering) student does not know how to perform some relatively simple analyses such

as reading and understanding an energy bill. Only 21% indicated they could so. Most found the instructions clear for the complex activities although earlier drafts had been amended following student feedback.

The acid rain effects or influence on the germination of mung seeds was a clear demonstration of the sensitivity of this seed to acidity but the results were "expected" by the bulk of the students (60%). Since a large number of students are familiar with the effect of acidity, a residential energy consumption estimation activity is used in the spring semester.

Most students found the group project to be "useful" in learning the material (81%) but as usual some teams (mostly self-forming) did have expected team frustrations and unequal participation for some members although overall many teams functioned well with 83% "strongly", "agree" or "Some what agree" that contribution was equal.

Table 2. Student Knowledge Prior to Performing the Projects

Question	Yes	No
Did you know how to read utility (energy bills) before the Home Energy Usage analysis activity	107	418
Did you know the acid rain effects on vegetation before doing this activity	313	212
Did you know how to analyze your energy bills to compare the relative costs of energy sources before performing Home Energy Usage Analysis Activity	46	479
Did you know the importance of insulation on home heating and cooling cost reduction?	209	316
The final project was useful in learning the subject matter	426	99
Choices for selection of the final project was useful	506	19

There was overwhelming support for the ability to choose group projects from a selection of options rather than being assigned projects. This is consistent with our student-centered philosophy of general education and significantly contributes to the enjoyment that the students derive from the course. Of course an enthusiastic instructor is also a prerequisite for successful and productive learning environment. The students have access to over 100 courses that can fill their credit requirements for general education natural sciences, thus to compete and generate substantial interest through enrollment new and innovative approaches have to be taken to better serve the students.

Table 3 presents the results from a questionnaire on the effectiveness of the course given during the last week of classes in the fall of 2003. Despite the course being activity heavy it did not require significantly more workload from the students. Thirty-five percent of students were uncertain if they had worked harder than other courses with 45% agreeing or strongly agreeing that they did work harder. This finding however is rewarding given that 84% of the class believed that they learned more ("Compared to my other general education courses at PSU, I feel I learned a great deal in this course"). The course was modified over the past two years in response to student feedback to ensure that the objectives and that the weighting of the grading was appropriate based on the students' energy expenditure.

It is strongly believed that part of the success in the course is because of the energy and effort placed on enabling the students to improve the quality of their work. This is not easily achieved with such large enrollment classes but the assistance of trained teaching assistants with the same quality-driving attitude was essential. This approach and the useful knowledge gained in the course help to produce outstanding student evaluations of the course. Particularly gratifying was the outcome that 78% of the students felt that high standards of excellence were set for the course. Finally the interest in the material was "moderate" prior to starting the course (remember that the students could have picked from 100 other courses) but as a consequence of taking the course the interest in the material had been elevated to "high" with an additional 23% of the class becoming "very interested."

Modifications made based on the assessment

The course was modified for the spring in response to student feedback to ensure that the objectives and that the weighting of the grading was appropriate based on the students' energy expenditure. The modifications also included on-line, interactive quizzes instead of 10 in-class quizzes making room for more in-class, small group activities to engage students more actively.

A new residential energy consumption estimation activity is used in the spring semester instead of the acid rain activity since majority of students felt that they were aware of these effects.

Summary

The active learning and project based approach has been successfully adopted and shown to be effective within a large enrollment class of non-technical students. The class is rated highly by the students and is a pleasure to teach because of the enthusiastic class participation. In comparison to other approaches used in general education classes at Penn State the students feel they work slightly harder but learn a great deal of useful knowledge and new abilities that traditional non-technical students are sadly lacking. Most importantly they are saving money while saving the planet and are moving towards being responsible citizens in our Global Village.

Table 3. Student Rating of the Course

Question	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
I worked harder on this course than on most of my other general education courses I have taken at PSU	41	200	184	94	10
Compared to my other general education courses at PSU, I feel I learned a great deal in this course.	145	296	63	21	3
The outside assignments (e.g., home activities and projects) were useful in helping me learn.	126	319	45	37	2
The in-class activities (e.g., discussions, small group work, demonstrations) were useful in helping me learn.	100	295	85	40	7
This course was one of the most difficult general education courses I have taken	32	99	113	234	51
The tests, home activities and projects focused on the objectives of the course.	208	292	20	4	4
The instructor was fair and reasonable in grading exams and home activities.	232	230	45	16	5
The instructor and/or syllabus provided an adequate description of the course and its requirements.	221	264	29	14	1
In class the instructor provided material beyond that offered in the readings	146	279	85	12	6
The instructor usually seemed well prepared for class and concerned about the students.	331	176	15	6	0
The instructor seemed enthusiastic about the subject matter.	433	88	6	1	1
The instructor was available to help with questions or homework outside of class.	266	189	64	8	1
High standards of excellence were set for the course	96	322	96	13	1
Overall, I consider this instructor to be an excellent teacher compared to other instructors at PSU.	207	233	62	19	5
Overall, I consider this to be an excellent general education course compared to other general education courses at PSU.	151	245	87	36	10
Exam preparation and review materials on the web were extremely helpful for learning the materials	342	150	24	8	3
	Very High	**High**	**Moderate**	**Low**	**Very Low**
Your level of interest in the subject prior to this course:	36	86	245	124	38
Your interest in the subject has increased as a consequence of this course.	159	227	116	20	6

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