

Energy Conservation Education for Non-Engineering Students and the Effectiveness of Active Learning Components

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Introduction

In the fall semester of 2001, the Department of Energy and Geo-Environmental Engineering initiated a drive to educate more students outside our majors in energy related subjects. A 3-credit general education course on “Energy Conservation and Environmental Protection” (EGEE 102) was developed and offered primarily for non-science/engineering students. Energy is a vital component of modern society. Much of the general population believes that the energy sources on which we depend are perpetual. While people believe that energy use is the culprit for environmental damage, they are not aware of the methods and principles by which energy conversion devices operate. This general education course provides students with information on, and increases their knowledge of the main operating principles of devices/appliances that are in common use. This will prepare them to make informed purchasing decisions by selecting the most economical and energy efficient appliances. These energy consuming devices include appliances, such as refrigerators, washers, dryers and ovens, and home heating and cooling systems and transportation vehicles. The course also provides energy related information on insulation, doors and windows, lighting, and air heating and air conditioning principles. The objective of the course is to educate students about energy efficiency in their daily lives in order to allow them to save energy (and money) and thereby protect the environment. This education is very important for all college students so that they can act as environmentally-responsible inhabitants of this Global Village.

Demographics of the student population:

EGEE 102 was first offered in the fall semester of 2001 in two sections with a combined enrollment of 69 students. Enrollment in four sections for the spring semester of 2003 is 432 students. Enrollment in each section was limited to a maximum of 120 students with the intent of maintaining class interaction and class discussion. The methodology used for learning and teaching is discussed later in the paper. Distribution data on the student population by major indicate that the course has been taken by students from 87 different

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majors. Students emanate from the Colleges of Arts, Liberal Arts, Business Administration, and Communications. In a given semester, the number of majors represented in the course varies between 30 and 42. The maximum percentage of students from a single major varied between 13 and 21% with an average enrollment of 2.2 to 3.4 students from each major. This highlights the diversity of the class population.

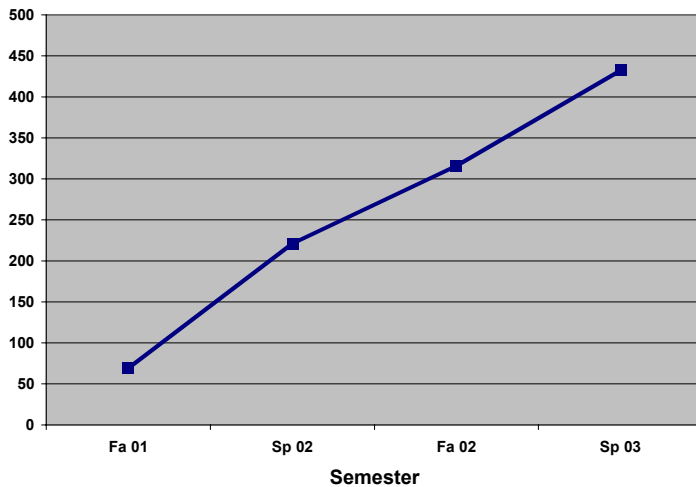


Figure 1. Enrollment data for EGEE 102 since its inception in fall 2001.

Since the students are from a variety of non-engineering majors, they tend to have a phobia towards science. Therefore, not only does the course need to cover the required science and engineering components but also needs to involve the students in the learning process, through active learning components which generate student interest.

Table 1 shows the distribution of semester standing of the students enrolled in the course. Between 56 and 71% of the students are freshmen or

sophomores, although there are students in their junior and senior years. Diversity in major, range in semester standing and phobia towards science and engineering make it difficult to keep the class interesting and challenging for the students with a wide range of abilities and expectations.

General Learning and Teaching Methodology

“Eighty- three percent of faculty nation wide report that lecturing is their preferred instructional method, even while surveys of students say that question-and-answer periods, team projects, work on problem-based activities and face time with the instructor were the biggest contributors to a positive learning experience”¹.

“The attention span of the students increases from the beginning of the lecture to 10 minutes into the lecture and decreases after that point”².

There is no formal text book for the course. Most of the lecture slides and reference materials are posted on the web. This is facilitated by the course management program: A New Global Learning Environment (ANGEL). ANGEL was developed by Cyber Learning and has been adopted as a course management system by The Pennsylvania State University.

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Table 1. Distribution of the Students by Semester Standing

Year	Semester	Section	Semester Standing (% Students)												Total
			1	2	3	4	5	6	7	8	9	Prov	NR	NC	
2002	Fall	1	5	23	7	32	9	8	7	7	1	0	0	0	100
		2	7	17	7	27	7	12	3	11	7	1	1	1	100
		3	3	6	20	28	13	9	6	13	1	0	2	0	100
2003	Spring	1	3	25	13	24	13	12	2	8	0	0	0	0	100
		2	4	25	17	26	11	7	3	4	4	0	0	0	100
		3	3	34	9	19	10	14	4	7	1	0	0	0	100
		4	16	34	10	13	4	14	5	3	0	0	0	0	100

The course uses multi media materials such as video clips followed by class discussion, and crossword puzzles to reinforce the terminology and facilitate problem solving.

Creating a Learning Centered Classroom

Group activities promote a collaborative and joint intellectual learning atmosphere as opposed to traditional lecturing by the instructor. The course entails various simple, in-class group activities, which reinforces the information presented in formal lectures and reactivates the students' attention³. The group activities include conducting a set of experiments and/or



Figure 2. Students brainstorming to produce a list of activities to reduce water heater energy costs.

gathering and analyzing data and presenting the observations later in the form of a written report. These activities sometimes involve in-class demonstrations. Figure 2 is a picture of students working in groups to generate a list of steps that individuals can take at home to reduce their water heater energy costs. This is not meant to be a laboratory course or a research project. However, peer-to-peer learning is found to be more effective than delivering formal lectures. Activities required for the course also include out of class collaboration. An example is students visiting an appliance store and measuring the power consumption of similar appliances and selecting the model that uses the least power when turned off (vampire power).

Another example of an out-of class collaborative learning experience is conducting a home energy audit while walking around a house, apartment, or dormitory. Students are required to take notes on crack openings, caulking condition, insulating materials used, details of the

heating system, windows, etc., and to suggest specific ways to conserve energy in the residence.

Problems with using Physical Models

The learning process is most effective when the students see and are involved in doing an activity. This is accomplished through a set of small experimental working models made with simple household items or craft ware. The pre-fabricated units are distributed in the second or third week of class to groups of students working with selected projects. The feedback from the students has been very positive around this activity. However, physically carrying the models was reported to be cumbersome by some students. With increasing enrollment, logistical problems in transferring these models among various groups in a timely manner and the number of models required has hampered our ability to continue with the number and quality of the home activities at the desired level.

Alternatives to using Physical Models

The expectations of students of the classroom learning environment today are different from those of their teachers. Even teachers' expectations of their students' work are changing rapidly. With the changing teaching and learning environment, teachers are expected to help students 1) acquire critical skills such as teamwork and presentation skills, 2) prepare them for life long learning and 3) use information technology advances for learning. Therefore, effective pedagogical practices require instructors to use whatever technology is appropriate



Figure 3. Screenshot of the insulation and energy conservation activity module

in order to assist student learning. The use of electronic technology provides faculty with a number of ways in which learning resources can be developed and used to enrich the learning experience. It also facilitates providing these resources on a 24/7 basis without time constraints.

There are several existing computer models that are being used in class. Two examples are: for fuel

economy or selecting a car, the US EPA site www.fueleconomy.gov/feg/findacar.htm; and for home heating costs, the home energy saver site hosted by Lawrence Berkley Laboratory at <http://www.homeenergysaver.lbl.gov/>. Most of the computer models or simulations that are currently available, such as the Home Energy Saver, have the disadvantage of being unable to demonstrate the scientific principles or logic behind the models. Another problem

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with these models is the number of parameters that needs to be entered (without sliders). Also problematic is the non-uniformity in the level of audiences they are designed or developed to serve.

Learning Heat Transfer and Thermodynamic Concepts through Computer Simulation

Learning the concepts of heat transfer (loss) though walls, doors and windows by conduction, convection and radiation is much easier by the use of physical models and experiments. With increasing enrollment it was necessary to find alternative methods to physical models without losing their interactivity. In the fall semester of 2002, a project was proposed to develop a web-based computer simulation to convey the principles of heat transfer (loss) though conduction in three parts. The Educational Technologies Services Unit of Information Technologies Services at The Pennsylvania State University demonstrated its support by selecting and funding this project in a competitive process. The ETS staff consists of instructional designers, programmers, graphic artists, and technical writers. This simulation was designed using flash simulation with javascript programming. The objectives of each of the three parts are as follows:

Part 1: To determine the most effective type of insulation in terms of R-values

This is accomplished by completing a virtual experiment as shown in Figure 4. Several boxes contain different insulating materials and are heated by incandescent bulbs inside. The exercise involves recording the temperature (Figure 5), graphing the temperature as a function of time, understanding the significance of R-values and calculating the R-value of a composite wall.

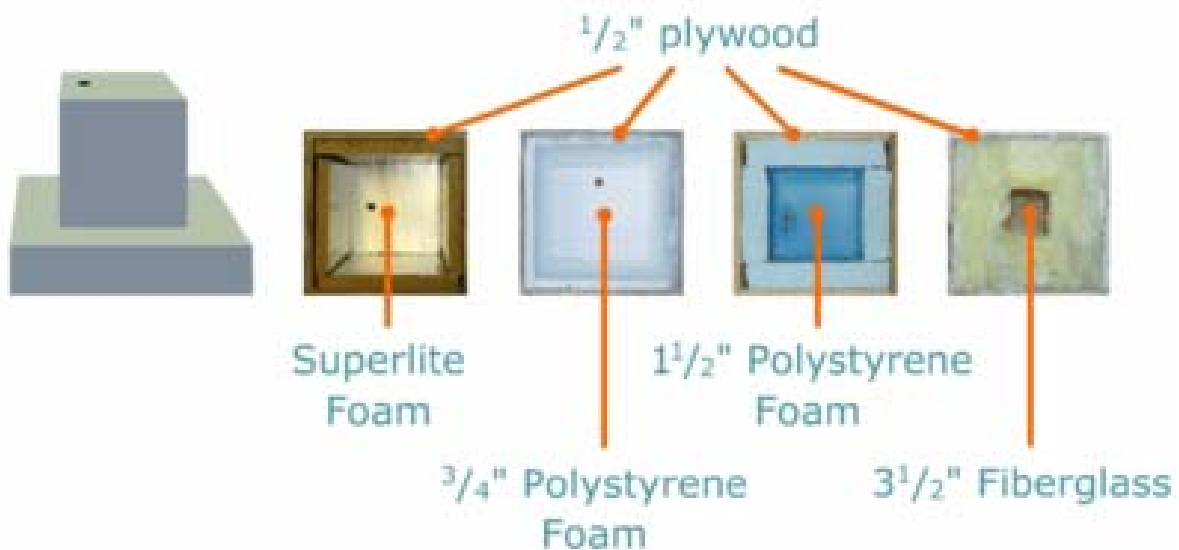


Figure 4. A screenshot of plywood boxes with various insulating materials

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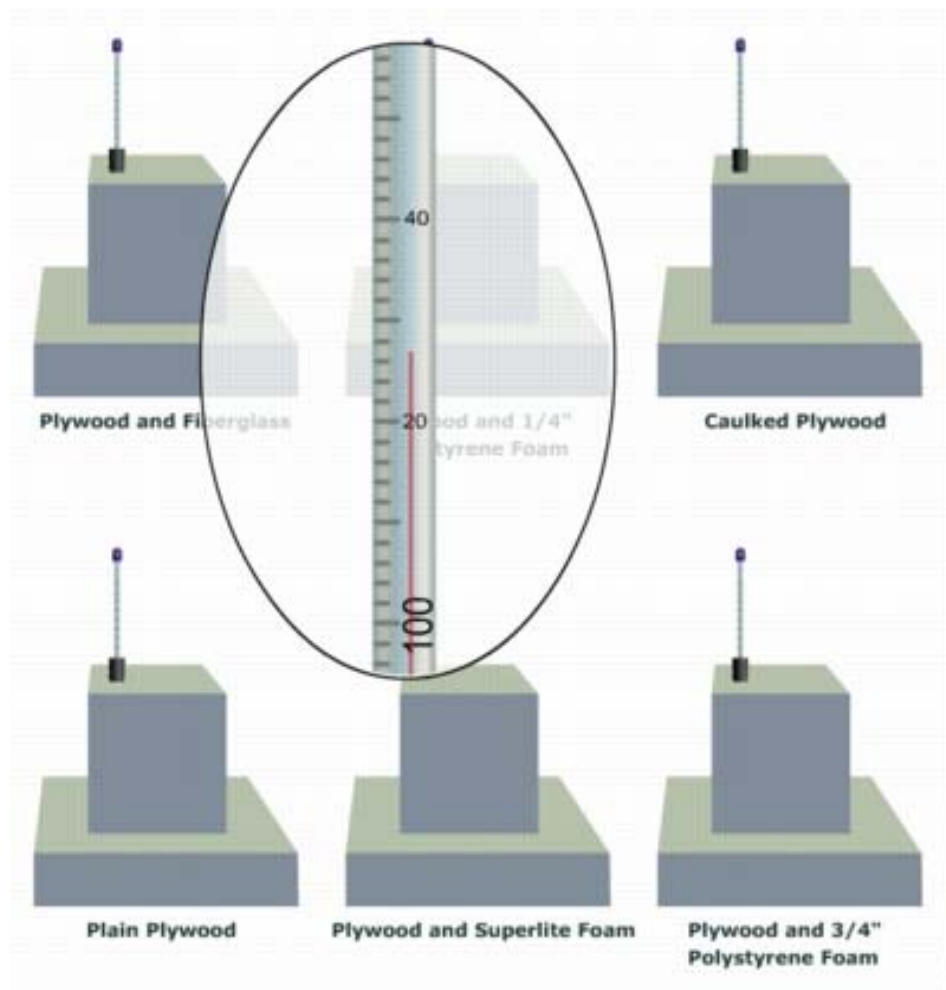


Figure 5. A screenshot showing the thermometer reading of one of the boxes

Part 2: To determine the cost effectiveness of various insulating materials

This objective is accomplished by obtaining current costs of the five different insulating 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 insulating materials are obtained by going to a home improvement store.

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

In all the modules, calculations are done by the students and entered into a table interactively. The simulation only provides guidance on how to calculate, thereby serving as a learning tool. A screen shot of this part is shown in Figure 6. The objectives of this part are achieved

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by determining the area of the walls to be insulated, the area of the windows and the roof, obtaining R values for each of these surfaces and calculating the heat loss per year using heating degree days for the selected location. It also involves calculating the investment for additional insulation and pay back period based on the annual fuel savings for different fuels. Students are required to write a short report on the findings and submit it through ANGEL.

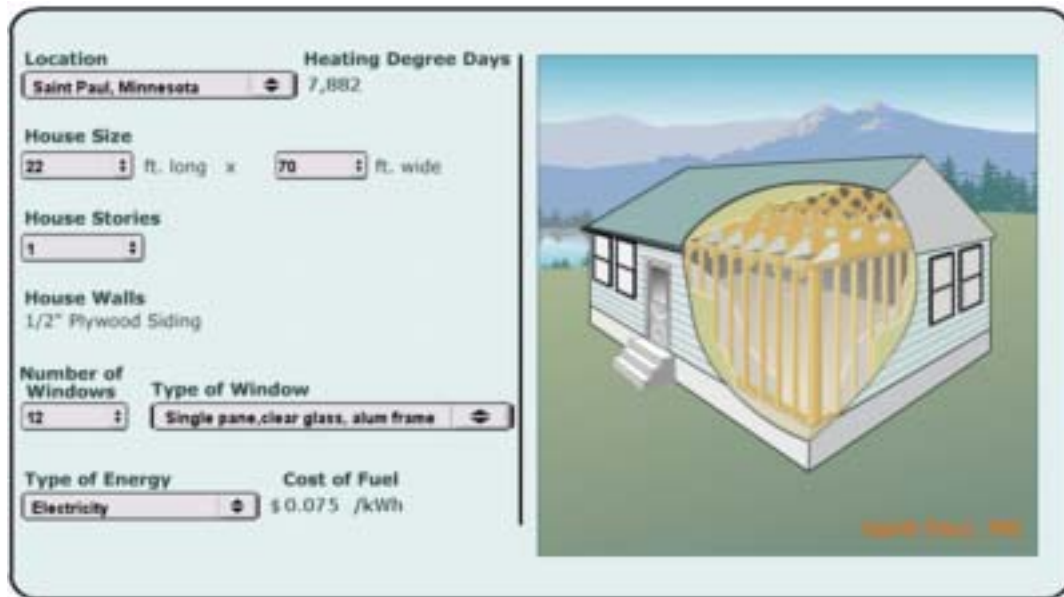


Figure 6. A screenshot of Part 3 of the insulation simulation.

Student Feedback on the Active Learning Components and the Interactive Classroom Environment

Student Evaluations of the Educational Quality (SEEQ) have been very positive. These evaluations are performed anonymously and responses for one class are tabulated in Table 2. Responses to questions 1 and 2 suggest that the course was intellectually challenging and stimulating, given the background and diversity of the students in the course as discussed earlier. A majority of students (71% recorded 4 or 5 on a scale of 1 to 5) felt that they learned and understood the material. Feedback to questions 3 to 6 indicates the degree of freedom and interaction in class lead to the success of the active learning components. The responses to questions 8 and 9 demonstrate clearly that this course generated interest in the subject matter and helped students to become life long learners.

Table 2. Summary of Students Evaluation of Educational Quality

No	Question	Students Response (%)				
		Very Poor	Poor	Moderate	Good	Very Good
1	You find the course intellectually challenging and stimulating	1	1	29	47	22
2	You have learned and understood the subject materials in this course.	2	8	19	51	20
3	Instructor is enthusiastic about teaching the course.	0	1	2	16	80
4	Students are encouraged to participate in class discussions.	0	1	16	27	56
5	Students are encouraged to ask questions and are given meaningful answers.	0	1	13	38	48
6	Students are invited to share their ideas and knowledge.	0	5	16	28	51
7	Readings, homeworks, etc., contribute to appreciation and understanding of the subject.	5	5	17	44	26
8	Your level of interest in the subject prior to this course:	19	34	33	12	3
9	Your interest in the subject has increased as a consequence of this course.	5	3	33	36	23

Summary

The use of hands on experimentation in a general education course on energy conservation enhanced our ability to reach out to a diverse, and often math and science phobic non-technical, college audience. As enrollment in the class grew, the physical limitation associated with presenting hands on experiences was overcome through the use of computer simulations that retained the “look and feel” of the original experimentation. Student interest in the material was enhanced via two “hooks”: saving money (home energy use) and saving the planet (pollution reduction). These approaches, combined with other activities (crossword puzzles, group discussions, etc.) produced a class that was highly enjoyable for both the teaching team and the students, and which received high student ratings. The success of this approach is evident by the fact that the course has generated interest in the subject matter and helped the students in their quest to become life long learners.

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