

2006-1732: DEVELOPMENT OF HIGHLY INTERACTIVE, ON-LINE COURSE ON ENERGY CONSERVATION: LEARNING STRATEGIES USED AND EXPERIENCE GAINED

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DEVELOPMENT OF HIGHLY INTERACTIVE, ON-LINE COURSE ON ENERGY CONSERVATION: LEARNING STRATEGIES USED AND EXPERIENCE GAINED

Abstract:

Energy Conservation and Environmental Protection (EGEE 102) course has been taught at Penn State since the fall of 2001. This course was selected by Penn State under the “Courseware Initiative” to be offered as an online course. To develop the online version of EGEE 102, the Energy and Geo Environmental Engineering (EGEE) Department, Teaching and Learning with Technology (TLT), and the John A. Dutton e-Education Institute have collaborated to generate highly interactive, innovative learning objects. As a part of this endeavor, activities using Macromedia Flash were developed. The goal of these simulations is to engage students through student specific data enabled animations and enable students to learn concepts through automated interactivity. Interactivity involves online puzzles, drag and drop, fill in the blanks, problem solving with audio narrations, and online flash simulations to check and monitor the online learning.

This course was taught online as a pilot version in spring of 2005 to 50 students. In fall of 2005 the course was subscribed by 350 students.

This paper discusses the experience during the piloting phase and usefulness of different teaching and learning strategies. The strategies used for online class are 1) variation in instructional strategies, 2) visual reinforcements of students' attention and reinforce their learning, and 3) opportunities for students to provide personal insights and interpretations. This paper also discusses the student feedback and analysis of learning strategies used.

Introduction:

In the fall of 2001, the Department of Energy and Geo-Environmental Engineering initiated a drive to educate more students from other departments 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. While people believe that the energy use is the culprit for environmental damage, they are not aware of the methods and principles by which energy conversion devices operate and how an individual can influence environmental protection by their actions. This general education course provides students with necessary knowledge and information on the main operating principles of devices/appliances that are in common use and information on which to make the right decision in selecting the most energy efficient and economical choice. In fall of 2001 the enrollment in the course was 69 and in fall of 2005 the enrollment increased to 860. This course was taught in multiple sections (six sections in fall of 2005) by the same instructor. Total enrolment trend is shown in Figure 1.

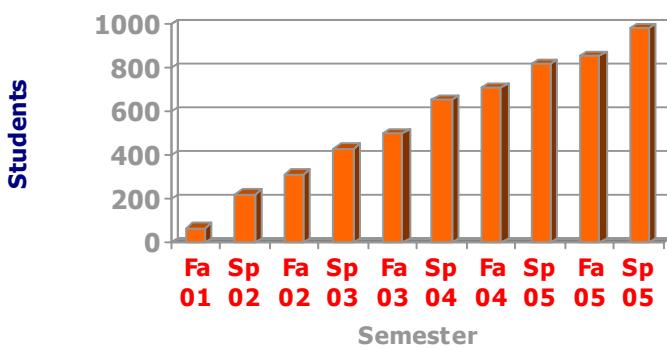


Figure 1. Total enrollment (online and face-to-face) trend for EGEE 102

In 2004, this course was selected by the University under the “Courseware” initiative to be offered as an online course. To develop the online version of EGEE 102, the EGEE Department (instructor), the Teaching and Learning with Technology (TLT) Unit of the University’s Information Technology Services (Instructional designer and multimedia developers) and the John A Dutton e-Education Institute (data base expert) have collaborated to generate highly interactive student specific data driven learning objects in an innovative manner.

Course Objectives

The main objectives of this course are to 1) provide basic understanding and appreciation of energy efficiency and environmental concepts; 2) learn basic operating principles of day-to-day energy conversion devices; 3) discuss various options to increase energy efficiency; 4) examine ways to save energy, and the environment.



Figure 2. Instructor's caricature that appeared in different outfits to stress important points or elicit the students' curiosity in a fun manner.

Instructional Design

The face-to-face sections of this course have been popular due to the warmth, enthusiasm and humor of the instructor. Thus, a major concern about moving this course from a face-to-face environment to a totally online environment was reduced student motivation and learning outcomes, since the students would no longer benefit from the instructor’s immediacy behaviors (Christopel, 1990). To overcome this obstacle, the instructor’s presence and personality were included in the course through a caricature that appeared periodically in the online lessons, simulations and audio explanations. The caricature was not stagnant, rather he was dressed in different outfits, placed in various situations and often

used dialogue bubbles to stress important points or elicit the students' curiosity. The instructor also made his presence felt by narrating all the animations and worked examples, and appearing in a number of videos.

The online lessons were text-based with embedded activities, animations, videos and worked examples. The content in each lesson was divided into small sections, and text design strategies were used to assist the student in selecting, organizing and integrating information (Mayer, 1999).

Specifically, objectives were listed at the beginning, titles and subtitles were added, important terms were bolded, and lists were bulleted. In addition, a series of icons were used to draw students' attention to interactive features.

Interactive activities were embedded in the lesson to encourage students to test their understanding on what they had just read. All activities included a "check answer" button, which provided immediate feedback. Examples of the activities include:

Examples of Interaction

Most of the day-to-day devices that we use are energy conversion devices. In this activity, you will identify the fundamental form of energy that is put in to the device and the output form of energy that is a result.

INSTRUCTIONS:

1. Enter only the first word of the input and output energy form in lower-case letters.
2. Be sure your answers are spelled correctly.
3. Click the 'CHECK ANSWER' button to check your work before moving on to the next device.

Lawn Mower 1 of 6



INPUT FORM OF ENERGY

OUTPUT FORM OF ENERGY

CHECK ANSWER

Figure 3. A screen shot of Interactive fill in the blank activity.

- Energy conversion fill-in-the blank activity, where students entered the input form of energy and the output form(s) of energy (Figure 3). The responses would be graded and feed back would be given instantaneously.
- A heat loss drag-and-drop activity, where students identified and then dragged images of different types of

heat loss from a house image into answer boxes labeled conduction, convection or radiation. A screen shot of the activity is shown in Figure 4.

- An animated temperature conversion activity where the students identified the freezing, melting and boiling temperatures of the Fahrenheit, Celsius and Kelvin scales after observing a block of ice melt in a frying pan and eventually heat up to a boil.

Videos were used to demonstrate complex topics that could be replicated in a lab or with model (operation of a power plant.) Animations were used when a concept was unfamiliar to most students, like the operation of a furnace or the response of “smart windows” to light; or if the concept being discussed depicted changes over time, such as the formation of greenhouse gases (Betrancourt, 2005). All videos and animations included learner controls to pause or reset the animations, which helped to improve learning outcomes (Mayer & Chandler, 2001).

Mechanisms of Heat Loss or Transfer

Instructions: First, identify the type of home heat loss pictured in images A-J as either: conduction, convection or radiation. Then click and drag each image down to the correct category at the bottom of the screen.

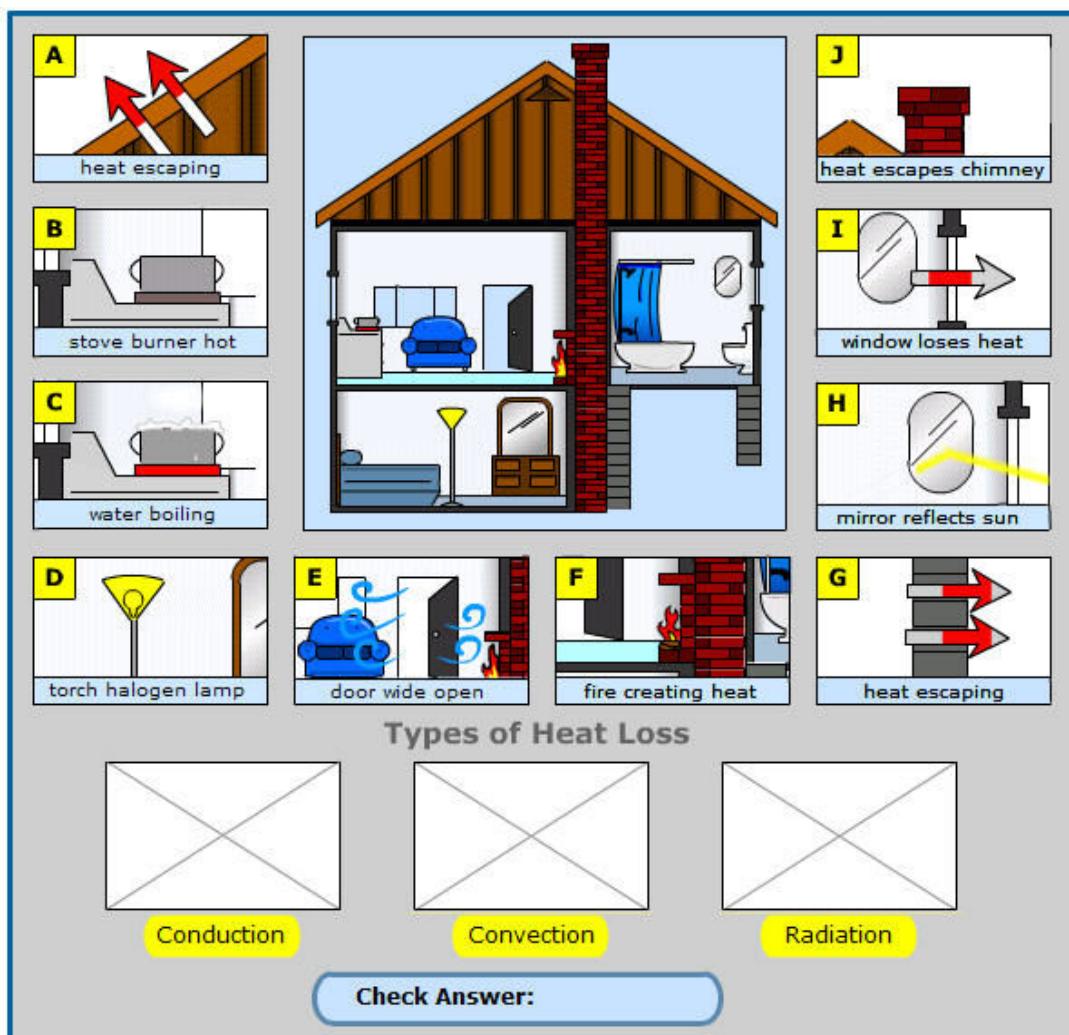


Figure 4. A screenshot of drag-and-drop activity to self assess the understanding of mechanisms of heat transfer

Worked examples were included in several lessons to assist the students in learning mathematical calculations. Worked examples, also called worked-out examples or worked solutions, include a problem statement, solution steps and the final answer (Renkl, Stark, Gruber & Mandl, 1998). Some worked examples were in a text format, sometimes with an accompanying image (Figure 5). These worked out examples have an infinite problem generator (using javascript) so that students can try on their own. If the students are not able to answer correctly, it will provide an explanation of the problem solution and give the students another problem to solve.

More complex worked examples were animated using software and tablet called “Belshazzar” (Miller, 2003) which enabled the instructor to write out the solutions to problems while explaining them. Worked examples that utilize aural explanations result in higher learning outcomes than those that use text (Atkinson, 2002). A screenshot of an example of dynamic explanation is shown in Figure 6. In accordance with the Cognitive Theory of Multimedia Learning, integrating the animation of the problems with the narrated descriptions allowed students to use both their auditory and visual channels, resulting in reduced cognitive load and more effective processing of incoming information (Mayer & Moreno, 2003).

In addition to the online lessons, students also completed four simulations. All simulations included the caricature of the instructor and were highly interactive. The simulations presented the students with practical, real-world situations where the knowledge they attained in the course could be put to use, such as calculating the cost savings from adding additional insulation to a house. The activities helped to motivate the student to learn the material because they could see its relevance to their future role of home owner. The simulations, which were graded, also assessed the students’ ability to transfer the knowledge they had gained from completing the online lessons.

Multimedia Development and tools used

It was determined from a multimedia perspective that one way to achieve change in learning modes was to include a significant amount of interactive learning objects throughout the course in order to keep students interested and engaged in the content being taught, as well as to inject the instructor’s personality into the course. Because of Macromedia Flash’s flexibility and the ubiquity of the Flash Player plug-in, it was the primary tool for creating these objects, which include:

1. Animated explanations of complex topics - these objects use a combination of graphical animation and explanatory text to guide students through understanding complex topics such as how a fluorescent light bulb works or how a solar water heater operates.
2. Self-assessment activities - these objects provide a way for students to evaluate their knowledge of a discussed topic immediately. Because answers are not submitted to a database or graded feedback is instantaneous and can provide explanation, if needed.

Illustration:

A 19 inch TV has a voltage rating of 120 Volts and it draws 0.067 amperes of current. What is the energy consumption when it is operated for 8 hours a day?

Now lets see the solution.....

Given that: Voltage rating = 120 V (Volts), Current drawn = 0.067 A (Amperes)

Step 1: To Find the energy consumption, use the formula given in the previous equation 1.1.

Energy Consumption = Power Consumption * Duration of operation of the appliance

But there is no power rating given in the problem. However notice that we have been given the voltage and the current rating and using the formula at the top of the page, we can find the power consumption of the TV and then use equation 1.1 to find the energy consumption.

$$\begin{aligned}\text{Power Consumption} &= \text{Voltage} * \text{Current} \\ &= 120 \text{ Volts} * 0.067 \text{ Amperes} \\ &= 8.04 \text{ VA (VoltAmperes)} \\ &= 8.04 \text{ W (Watts)}\end{aligned}$$

Now,

$$\begin{aligned}\text{Energy Consumption (in Wh)} &= \text{Power Consumption} * \text{No.of hours} \\ &\quad \text{operated} \\ &= 8.04 \text{ Watts} * 8 \text{ hours} \\ &= 64.32 \text{ Wh}\end{aligned}$$

Step 2: To convert from Wh to KWh, set up a linear equation and solve for "Y"

$$\begin{aligned}1 \text{ KWh} &= 1000 \text{ Wh} \\ Y \text{ KWh} &= 64.32 \text{ Wh} \\ \text{Therefore } Y &= 64.32 \frac{\text{Wh}}{\text{KWh}} \times \frac{1 \text{ KWh}}{1000 \text{ Wh}} \\ \text{Energy Consumption (in} &= 0.064 \text{ KWh} \\ \text{KWh})\end{aligned}$$

Why dont you give it a shot now.....

A vacuum cleaner has a voltage rating of 120 volts and draws 10.24 amperes of current. What is the energy consumption of the vacuum cleaner when it is operated for 23 hours per day?

Your Answer :

Figure 5. An example of a numerical problem (explanation) with an infinite problem generator for students to practice.

Calculate the heat loss for a 10 ft by 8 ft wall, insulated to R-value 22. The inside temperature is maintained at 70° F. The temperature outside is 43° F.

Inside Temp = 70 F
outside Temp = 43 F
 $\Delta T = 27^{\circ}\text{F}$
 $A = 80 \text{ ft}^2$
 $R = 22 \frac{\text{ft}^2 \cdot \text{F}}{\text{Btu}}$

$$\frac{Q}{t} = \frac{A \Delta T}{R} = \frac{80 \text{ ft}^2 \times 27^{\circ}\text{F}}{22 \frac{\text{ft}^2 \cdot \text{F}}{\text{Btu}}} = 98.2 \frac{\text{Btu}}{\text{h}}$$

Click PLAY to view the solution.

LISTEN UP!

REPLAY

Belshazzar

Figure 6. A Screen shot of dynamic explanation using Belshazzar and a caricature of the instructor.

3. Factoid boxes - these animated text boxes provide additional information about course content such as interesting facts pertaining to a discussed topic, review of background information for a topic, additional practice problems, or warnings about common troubles that students have faced regarding a topic in the past.
4. Video delivery - because the instructor utilizes several props in the classroom setting to illustrate key lesson points, examples were videotaped, edited and delivered via Flash in order to provide the similar experience to online learners.
5. Belshazzar - this technology allowed the instructor to simultaneously capture voice and dynamic pen stroke, and then save both as one Flash file. In this course, Belshazzar was used to explain complex graphics and chart diagrams as well as for providing solutions for calculations which students perform throughout certain lessons.
6. “Home” Activities - there were four of these activities developed using Flash. They were designed to help students apply knowledge gained in the course in real-world settings. For our online activities we use Macromedia Flash, PHP 5, Apache 13.29, and MySQL 4.1. Flash, of course, is proprietary and runs in a web browser, but the other technologies are open source and run on Dell servers using the Red Hat Enterprise Linux 3 operating system.

The first step each semester is to load the student information into the roster table in the database. This is a manual process as we are not tied into the University's registration system. In this student table, a Penn State-issued login ID is used as the primary key. These login IDs are used by the authentication system also. Whereas our servers are housed in the College of Earth and Mineral Sciences, they authenticate against University servers. The students use the same ID and password that they use for other University technology services. In another table, information is entered about course section, each of which has a unique numerical identifier that links to a course name and semester.

The list of graded assignments (for each section) is loaded into the grades table. All graded items, exams, quizzes, online activities are put into the system.

Home Activity 2 - Energy Usage Analysis (Screen 1 of 12)

Introduction

The objective of this activity is to:

- Analyze the home energy usage pattern.
- Determine the relative percentages of energy sources you depend on and the relative costs of each of those energy sources.

Procedure

- Print table (pdf format).
- View virtual gas and electric bills.
- Enter information into the printed and online tables.
- Plot graphs for gas and electric consumption.
- Respond to questions based on analysis of energy usage.

Lion Power
A Nittany Energy Company
Service Location: 1003 Beneroya Avenue, State College, PA 16801
Your Electric Use

Month	KWH Used
JAN	8,500
FEB	7,500
MAR	6,500
APR	5,500
MAY	4,500
JUN	3,500
JUL	2,500
AUG	1,500
SEP	1,000
OCT	1,000
NOV	1,000
DEC	1,000

*** See Next Page for Details

Nittany Gas
A Nittany Energy Company

Billing Summary For:
1003 Beneroya Avenue, State College, PA 16801

Billing Period	Days	Meter Readings	Gas Used
02/07/03 - 01/09/03	29	643610 - 6436 = 100 CFF	100 CFF
Actual			
Estimated			

Billing Information

Item	Description	Amount
100 CFF at \$5.50396 / CFF	50.40	
Monthly Customer Charge	10.81	
State Tax Adj Surcharge	-0.03	
Balance Due	\$ 61.18	

Meter Information

Meter Number	Billing Period	Days	To	From	Gas Used
V265159	02/07/03 - 01/09/03	29	643610	- 6436	= 100 CFF
	Actual				
	Estimated				

Consumption History

Month	Gas Used
JAN	300
FEB	250
MAR	200
APR	150
MAY	100
JUN	50
JUL	50
AUG	50
SEP	50
OCT	50
NOV	50
DEC	50

For More Information About Your Bill, Click Here to See Reverse Side.

Continue

Figure 7. A screen shot of an interactive home activity (homework) to analyze home energy bills

For each online activity, there are unique initial values for each student. These are generated randomly, within real-world parameters, and entered into the database. Each online activity has its own database table with a record for each student. In addition to the initial values, any answers the students submit will be stored here. Most of the work of putting data into the database is done using Perl scripts and is accomplished very quickly.

When a student logs in (securely) for a Flash-based activity, the login ID is sent to the database and is used to extract the unique initial values associated with that student. The

Flash movies are populated with these values. The student completes the exercise, typing in numerical and textual responses to the questions posed. The data are submitted to the database at the conclusion of the exercise. The students may repeat the activity multiple times before the assignment's deadline. For each submission, the previous data are overwritten.

Because students are somewhat apprehensive about online assignments, we created a separate web page for each assignment where he/she can view the values they submitted. This helps to cut down on the invariable emails that ask, "Did you get my assignment?"

After the deadline for the assignment is passed, the graders use another web page to view the students' submitted work. On this page, PHP scripts duplicate the students' calculations to help graders find the student's errors and give customized feedback. There are form fields on this page so graders can grade the assignment and make comments. As soon as this occurs, students can see their grades and comments online.

All the graded items in the class, not just the online assignments, are included on the student's 'grades page.' Their final course grade is also automatically projected, with an accompanying letter grade.

For some graded items, quizzes for example, the lowest two scores of ten may be dropped when the final course grade is calculated. The 'grades page' counts all of the quizzes until nine are graded, then the lowest grades are dropped. For example, one of the Home Activities deals with home energy consumption (Figure 7). Students were given a year's worth of virtual electric and gas bills and recorded individualized data about energy usage. Once data was recorded and graphs generated showing the energy usage for a year, students then comment on the patterns they saw, do calculations based on the data obtained and then write a short essay about the environmental effects of their energy consumption profile. Once completed, the data is then submitted to the database and graded.

The challenge with working with this type of complexity in conjunction with larger-enrollment courses is the myriad of system configurations (operating systems, browsers, plug-ins, etc.) and bandwidth levels that need to be accounted for. Because of issues related to these differences discovered during testing, a short four-part Test Activity was developed which walks students through the process of checking for the correct versions of Flash Player and Adobe Reader plug-ins, enabling Java Script in their web browser and testing submission to the database by submitting data and checking the results. A detailed paper on these activities can be seen elsewhere (Pisupati, 2005)

Student Feedback

Students Rating of Teaching Evaluation (SRTE) was given to the students electronically at the end of the spring and fall semesters of 2005. The data was gathered anonymously. At the end of the spring 20 out of the 37 students who completed the course filled out the evaluation form. In fall semester, 161 of the 318 students who finished the course filled out the form.

The overall rating of the quality of the course has gone up from 4.2 (spring 05) to 4.8 (fall 05) and the overall quality of the instructor has gone up from 4.6 (spring 05) to 5.3 (fall 05) on a scale of 1-7. These scores are lower than the scores that were obtained for face-to-face sections taught by the same instructor during the same semester. For the face-to-face section the overall quality of the course ranged between 5.47 and 5.93 and the overall quality of the instructor ranged between 5.99 and 6.40. This trend of lower SRTE scores for online courses compared to face-to-face course is observed for other courses within the college. In addition to these overall ratings, the following questions were asked for written (textual) response.

Q1. What did you enjoy most about the course?

Q2. Which part of the course did you enjoy least?

Q3. In your opinion, do you feel EGEE 102 is lacking anything? What would you like to see improved?

The responses to those questions are textual. Only 121 out of the 161 students opted to give written comments about the course in fall 05. These responses were categorized into 13 overall topics and the number of comments under each category are shown in Table 1.

What did the students like?

From the comments such as “*I liked the material. I found it interesting. Also, I do enjoy not having to actually attend class and that I can do the lessons at home or wherever.*”, “*Flexibility on ANGEL, but more importantly - opportunities for students to engage in discussion and truly learn how to conserve and protect our energy resources and environment*”, “*I enjoyed the fact that it was online and I could work at my own pace*”. Based on the number of students who mentioned flexibility some way, it is apparent that students liked the flexibility in schedule, pace and organization. The demographics of the student population are changing. About 59% of the student population enrolled for this class work part-time or full time. Taking an online class is an advantage for most of these students. The content also was interesting to a lot of students.

Comments like “*I enjoyed learning about energy consumption and how to save energy and about cost efficiency. I have never had to pay an energy bill before so it was interesting to think about these things*” and “*I enjoyed the presentation of the material and Dr. Pisupati's willingness to teach. I enjoyed reading the lesson material each week. It felt like I was actually learning something*”, “*it (course) is useful in the real world*” indicate that students enjoyed the content – learning about energy efficiency, saving money and environmental protection. Some students specifically mentioned that multimedia such as animations; audio and video were helpful in learning the content and made the course more fun. Students made comments like “*The presentations in the lessons were very helpful, and the interactions within the lessons helped me grasp a better understanding of the material*”, “*I enjoyed the fact that the activities were virtual. I also thought the quizzes, crossword puzzles, activities and practice questions were very effective. They helped me to remember material for exams and were good study tools so*

Table 1. Student feedback on online version of EGEE 102

Category	What did you enjoy most about the course? (%)	Which part of the course did you enjoy the least? (%)	In your opinion, do you feel EGEE 102 is lacking anything? What would you like to see improved? (%)
Animations	11.2	0.0	0.0
Puzzles	8.6	1.5	1.1
Audio and Video explanations	11.2	0.0	1.1
Assignments and Home Activities	11.8	1.5	0.0
Projects	2.0	11.1	1.1
Exams and Quizzes	3.3	37.0	0.0
Communications	2.0	11.1	0.0
Clarity, organization and ANGEL	3.3	8.9	14.9
Learning Style (online vs. Face-to-Face)	0.0	6.7	20.7
Overall course or General	3.9	3.0	6.9
Nothing	3.3	5.9	51.7
Content	15.8	13.3	2.3
Flexibility (timings, pace etc)	23.7	0.0	0.0

I'm glad they were there", "I liked how the lessons were broken up into slides. It made them more interesting and easier to read. When things are in textbook format, it is really hard to read while staying interested. I learned more through the materials because they had little activities/questions on them and animation. It really helped me retain the information"; "I like the videos that showed how to do the math equations. Also, I like that I can apply the knowledge to my own life", "The video clips of the professor's instructions", "I enjoyed the pictures and cartoons of the professor during the lessons. They always made me laugh, especially when he was shivering in the cold house until the heat kicked in. It was just hilarious".

What was not liked by the students?

From the feedback (Table 1) it is clear that students had some trouble with exams and quizzes. At the end of each lesson, a practice test was posted which can be taken any number of times. These were graded only for self evaluation and the grade obtained did not count for their course grade. Since these questions were pulled from a database of questions, each time they chose to take it, they saw some new questions. Initially, the practice questions were all true or false to understand the concepts and quiz questions were all multiple choice questions combining 4-5 true or false questions. Since the format was not similar to the practice questions, students had difficulty with some questions and some students felt that the practice questions did not help in taking quizzes or exams. Comments like "*Quizzes didn't always seem to reflect the "important" material presented in the lessons", "Quizzes every week. Sometimes the quizzes were completely different from the self assessment", "the quizzes every week, because they were really difficult, they are more difficult than the exam, which is odd*" show that concern.

However, the practice questions were changed to multiple choice format midway through the semester and a study guide was provided highlighting the important concepts that students need to concentrate on. Comments like – "*the tests. I felt a study guide would have helped out and a little later in the course we were provided with one*" indicated that they like straight forward questions and study guides.

Another difference in this course was the location where they take the exams. Students were allowed to take quizzes and exams at home. Students who opted to come to a classroom were given an opportunity to come to a computer laboratory at a scheduled time to take the exams. Although the average time students took to complete was only 75% of the time given, several students felt that the time provided was not enough to complete quizzes and exams. However, it is also important to note that no one was able to score 100% on any exam.

The students were required to do a project and prepare a webpage on their findings so that the rest of the class members can learn their findings. This was one of the ways to present their work to other students in an online course. Two help sessions to teach the basics on how to create a webpage and on how to upload the materials onto the server were held during evening hours. Several students commented that they did not think it was necessary to create a webpage for this course. Comments like: "*Creating the web page. I do not understand why this was necessary for this course. Especially since we did*

not have that long of time to complete it”, “I didn't like the final project in that it had to be a website. I just think that making a webpage is a difficult task that people not involved with computers too much would suffer in. I luckily had just taken a class about it, so it wasn't that bad, but otherwise I think it would be really hard”, “the web site project. I don't think we should have had to make a web page, as it had nothing to do with what we had done previously in the class” show that sense.

Another important feed back was on communications. Most of the deadlines for items such as quizzes, self assessments, lessons and exams, dates for office hours (face-to-face meetings for online students) before the exams were posted on the calendar on ANGEL. ANGEL is the course management system (CMS) available for use by instructors, students, and staff at Penn State. There is a course announcements page that highlights the schedule for the week and displays the announcements. Email was also used extensively for communications. The instructor received 893 emails during fall of 2005 for this online section. The instructor sent or replied to students' email 1,020 times. That is an average of 92 emails sent per week. The course also had a TA who received 797 emails and sent 397 emails. The average email flow rate was 35 per week. The communication tools used for this course are listed in Table 2.

Table 2: Communication tools used for the online EGEE 102 course

Task	Tool	Method
Extending discussion beyond the class material	Message Board	Asynchronous
Having students turn in work in digital format	PHP Scripts My SQL database	Asynchronous
Sharing and annotating a graphics	Macromedia Captivate Camtasia Studio	Asynchronous
Assigning a project to students, and partial grading	PHP Scripts My SQL database	Sync. & Async.
Taking students on a "virtual tour" of "How to's"	Macromedia Flash	Asynchronous
Sending updated information	E-mail, Course webpage	Asynchronous
Reinforcement of Problem solving skills	Javascript Belshazaar	Asynchronous

From the number of students who commented about the confusion of deadlines or lack of communications, the importance of communications for an online course unlike a face-to-face course cannot be over emphasized.

"I think that this course could be improved if we were given more notification of assignments. I would not find out about a quiz until the night before it is due or sometimes the same day it is due. I check Angel many times a day so it was not because I neglected to look", "Deadlines were somewhat easy to miss which happens a lot with online courses", "The multitude of deadlines, and the large amount of requirements", suggest that the deadlines have to be communicated through multiple methods and students should be reminded often through email.

Most of the comments on content were about the math that was involved. *"the math and calculations: some of those were very difficult to understand" "Some of the mathematical aspects of this course were either not explained well enough or were too confusing for a basic level course", "I did not enjoy the math problems within each lesson. Why? Because I am not good at math" and "I didn't enjoy the math. The math is something that definitely needs to be taught in-class. But then again, I don't get along well with math."*

Since this course is subscribed by non-science and non-engineering students, this highlights the precautions that the instructors have to take. The effectiveness and importance of video explanations of mathematical problems using Belshazzar can be understood by comments like *"I like the videos that showed how to do the math equations. Also, I like that I can apply the knowledge to my own life"* and *"the flash instructions by professor. He did a great job explaining things"*.

What can be improved?

More than 50% of the students felt that there is nothing or not much that needs to be improved. Comments like *"I do not feel that it is lacking anything. Even when there was confusion, answers were posted with audio feedback from the professor. The professor really tried to make sure that everyone understood everything"*, *"I thought the content was fine. I think the grading for the online course was fair and the instructor listened to our suggestions during the semester that helped the students"* However, some students felt that the organization and clarity with respect to what needs to be done and when it needs to be done has to be improved. This can be inferred from comments like *"The organization of this course was a little confusing at times. It was hard to keep on top of things due to it being online, but that was my choice. I think that questions on exams could be made to be more relevant to what was in quizzes and highlighted as important"* As discussed in the previous section, the challenge seems to be keeping students informed about the due dates. Students made comments like *"Having emails sent every week to remind students of assignments that are due for the week.. I found myself often forgetting to do assignments because I wasn't aware that they were due without being reminded everyday in the class. I realize that having the calendar up when logging in, was very good but I often over looked it"* Students like straight forward questions and ample time to finish the exams. Several students felt that more time to finish quizzes would be appropriate.

Another important message is that most students like the flexibility of online classes yet would like to have access to an instructor on a regular basis. Comments like “*I would like to see more of a teacher student direct relationship. More interaction with the teacher in videos or help*”, “*Possible in person activities. Like bonus points for going to demonstrations on EGEE topics*”, “*Every section should have their own office hours. I felt as though the office hours were crowded and unorganized*”, “*...an online course where the instructor is not readily available should not be just as intense, or more intense, than a course where I can ask questions and have them answered right there and then*”.

It is felt that blended or hybrid course where students would be required to meet 6-10 times over the semester to do activities in class and/or for problem solving would be more appropriate for such students.

Conclusions

An online version of Energy Conservation and Environmental Protection course was developed. To incorporate the face-to-face teaching style of the instructor, the online lessons were text-based with embedded activities, animations, videos and worked examples. Interactivity involved online puzzles, drag and drop, fill in the blanks, problem solving with audio narrations, and online flash simulations to check and monitor the online learning.

Student feed back indicated that students enjoyed the content – learning about energy efficiency, saving money and environmental protection. Students specifically mentioned that multimedia such as animations; audio and video were helpful in learning the content and made the course more fun. The impact of the highly interactive multimedia can be easily seen in the enrollment. The enrollment in the online version has increased from 50 during the first semester to 318 in the second semester and to 450 in its third semester of offering. It is also apparent that students liked the flexibility in schedule, pace and organization.

An important message that came out of this student feed back is that online course instructors should highly emphasize communication of course deadlines, expectations not just once in the syllabus but multiple times in multiple ways to keep the students informed. Most students liked audio explanations of numerical problems and other feedback. Following numerical problems online was difficult to some math-phobic, non-science students.

More than 50% of the students felt that there is nothing or not much that needs to be improved. Some students indicated that they like the flexibility of online classes yet would like to have access to an instructor. It is felt that blended or hybrid course where students would be required to meet 6-10 times over the semester to do activities in class and/or for problem solving would be more appropriate for such students.

Acknowledgements

The authors would like to acknowledge Penn State University Provost's Office for financial support for this Development. John Harwood, Teaching and Learning with Technology (TLT) of Informational Technology Services; David DiBiase, John A Dutton e-Education Institute; Jonathan P. Mathews and Semih Eser, Energy and Geo-Environmental Engineering Department are also acknowledged for their constant encouragement.

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