Online Teaching of "Energy & The Environment"

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Abstract
In the Fall of 2002, the Department of Energy & Geo-Environmental Engineering (EGEE) in collaboration with "The John A. Dutton e-Education Institute" (College of Earth and Mineral Sciences) offered a 3-credit web-only version of the existing resident class "Energy & the Environment" at The Pennsylvania State University. The goal of the project was to enable students at any of the University's 25 campus locations, including its virtual "World Campus," to participate in the same high-quality, online, learning experience. Expected outcomes included increased enrollments (overcoming room availability issues) and, by virtue of the fact that students would be enabled to study at times and places most convenient to them, a more student-centered learning environment than is typically encountered in large classroom settings. The methodologies and techniques employed to transform an existing lecture-based resident class into a compelling and engaging web-only learning environment are discussed. The goal of this paper, then, is to report what is entailed pedagogically, institutionally, and individually in such a large-scale project in online teaching and learning. Opportunities for formal evaluation of student engagement, and of the relationship between engagement and learning, are also discussed.

Designing and creating an engaging, interactive experience, structuring content for web delivery, and maintaining the dynamic presence of the professor within a virtual environment were all important in the design decisions. The primary challenges were revising the class content to make it appropriate for independent learning, taking full advantage of the technologies and flexibility of the web environment, and enhancing the student-faculty communications despite all interaction taking place entirely across multiple-campuses via an asynchronous network. The application of numerous web-based technologies permitted more interactivity throughout the course resources. Examples of some of these techniques include: mouse-enabled dynamic text and visuals, animated images, charts, and graphs, flash animations, user-controlled 3-D molecular graphics, interactive concept maps, and various computer-based quizzing tools (enabling learning through both success and failures).

Combined, these approaches increased the level of active learning in the course, and the professor's dynamic nature and personality remained quite intact throughout the course through the use of audio, images, movies, writing style, and various communications channels (audio emails, written emails, and threaded discussions) afforded by the course management system and web environment. Together, these approaches produced an engaging online environment for

students, and helped to propagate the movement away from a class of text-heavy online reading towards a one-to-one (student to faculty) student-centered learning environment. The experiences, frustrations, and successes are discussed here from the faculty perspective. The goal of the paper, then, is to report what is entailed pedagogically, institutionally, and individually in such a large-scale project in online teaching and learning. Opportunities for formal evaluation of student engagement, and of the relationship between engagement and learning, are also discussed.

The creation of an online version of a successful resident class was an expensive and time-consuming endeavor. The course development process (which included the course's first semester as a "Web-only" offering) lasted approximately one year, and absorbed approximately one person-year of the combined efforts of a faculty author, an instructional design specialist, and numerous support and administrative personnel. The project relied upon the provision and maintenance of an enterprise course management system (ANGEL, created by CyberLearning Labs) by the University's Office of Information Technology Services. The benefits of such an endeavor was: increased student enrollment, and increased exposure of the environmental and energy issues facing the engineering disciplines of the department (Mining, Petroleum & Natural Gas Engineering, Environmental System Engineering, and Geo-Environmental Engineering). It was also envisioned that with the technological advantage of a computer for every student that the class can be presented with greater student interaction with the material, and perhaps increased opportunities to promote the thought process than an in-class delivery. The asynchronous delivery in a student-centered approach permits students to access the material at a time of the day when they are "primed" for learning. The hope being that the students' will enhance their retention and understanding of the material.

Student-Centered Design

Designing activities, experiences, and resources that are student-centered implies placing emphasis on the both the learning process and on the active processes that students undertake rather than emphasizing the transmission of information. In this student-centered model, the faculty becomes facilitators instead of lecturers, and students from knowledge consumers and rote learners to knowledge builders, creators, and users. With this overall design goal in mind, the majority of the EGEE 101 team's design efforts took place in four areas; Dynamic, Interactive Content; Assessment & Feedback; Learning Community Development & Communication; Student Management.

I) Dynamic, Interactive Content
The facet of online learning that gets perhaps the most attention from the instructional community is the continuous effort to turn learning activities online into more interactive experiences than their classroom counterparts. Definitions vary widely about what defines learning material and activity as "interactive", but the common thread is the notion that students are given greater level of control over the progression and display of the material and over the timing and sequencing of instructional events. How this is accomplished varies widely, and can take the form of a simple click of the mouse, the input of data, choices in the information presentation options, or real-time movement of objects or positions within a virtual environment. Students value interaction in their online experiences because it shifts part, or all, of the control

of the activity away from the instructor or teacher and towards the student. Not only do today's students *value* interaction of this nature and a sense of control over their learning, they increasingly expect it in their online environments.

Examples of the ways in which the EGEE 101 team created interactive materials for the course took many forms:

Dynamic Text, & Animated Images, Charts, & Graphs:
Insuring that the EGEE 101 online experience was not merely an exercise in online reading (or printing) for students, a great deal of both time attention went into creating and developing visuals that forced students to work a little and find connected information. The subject matter (the environment and energy) permitted copious use of royalty free government imagery, photography, and charts. The constant availability of a pocket-sized high quality digital camera accompanying the primary author also provided many images.

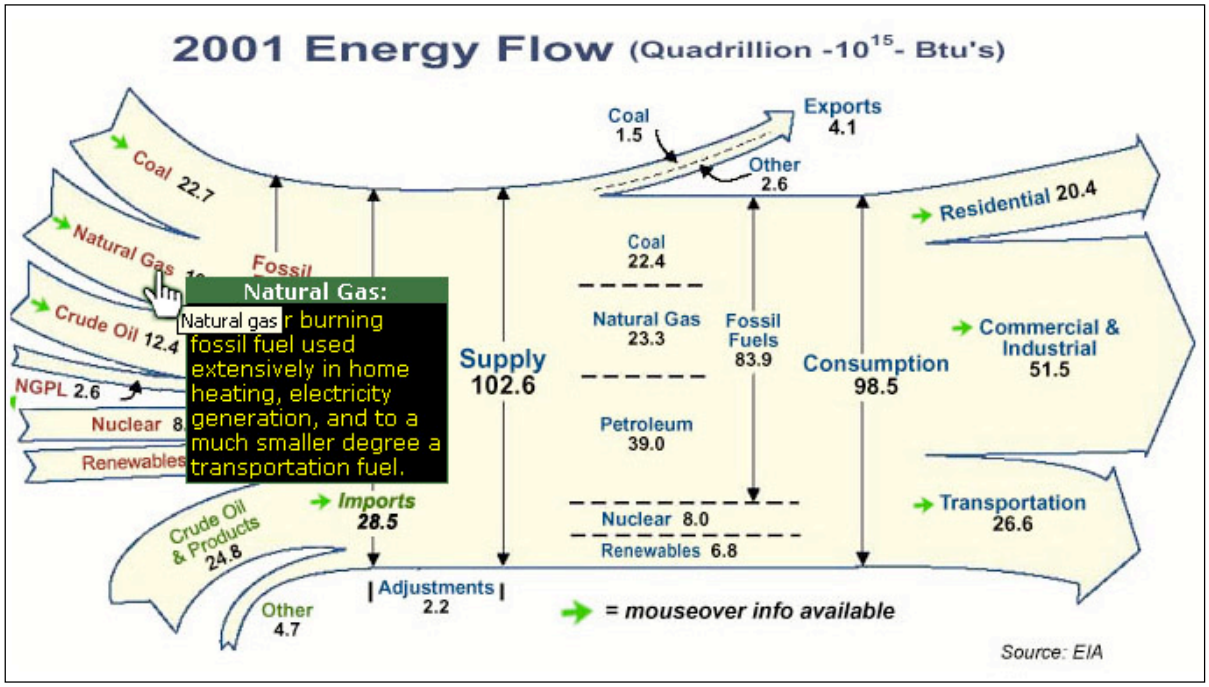

Figure 1. Having students interpreting graphs and charts was an important objective for the course, and many graphs and charts were enhanced with interactive components that helped connect concepts from other areas in the course.

Interactive Concept (Coverage) Maps:
Coverage maps are also used to help "tie together" material and lectures. They work as visual organizers for each lesson. An example of such a map is shown in Figure 2. These served as visual references to the material, climate change in this case, and the inter relationships between issues[1, 2]. In the Trepagnier study[2], 66 out of 67 students interviewed agreed or strongly agreed that drawing concept maps helped them understand sociological concepts. The enhancement here was the inclusion of dynamic text that appeared as the mouse passed over a topic. Hence they "tied together" the material and served as a lesson overview.

Coverage maps were presented in separate pages at the end of or in the middle of each "lesson". They tended to be accessed more frequently than other class material (from server logs reports). From a student survey, 73 % of the students found this either useful or very useful to their understanding and retaining the information. We are looking at ways of enabling students to easily draw concept maps within web pages so we can recapture that advantage. The use of mouseover techniques was also used to reveal definitions, information within graphs and schematics and also in definition reminders. It is a useful technique in engaging the student to interact with the page. By providing text that cannot be easily printed hopefully provided emphasis to the information and required note taking, which one might assume enhances the retention of the information.

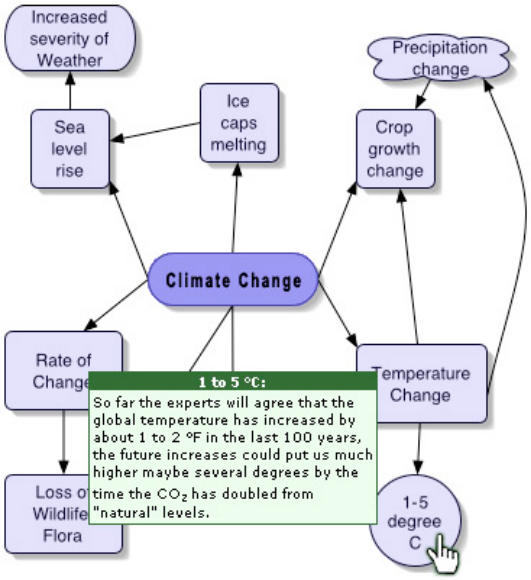

Figure 2. An example of one of the course concept maps used to help students organize concepts and understand connections between them.

Figure 3.. This "still" is taken from one of the many video demonstrations, this one showing oil quality issues.

Multimedia Presentations:

Audio files were also used to replace, and enhance textual information. Surprisingly, audio files are not frequently utilized within the World Wide Web. The primary author considers the use of audio highly advantageous as it can replace text and add a touch of personality into a web-only based class environment.

I enjoyed the animations, audio, and video very much. They broke up the monotony of reading and were fun."-

In addition to significant use of audio, a witty narrative style and commentary (relating to youth (MTV?) culture) was also used extensively throughout the course to give it pep and increased relevance to perceived student interests. Finally, the use of over 60 QuickTime movies, most only a minute or two long, added an immeasurable amount of life, personality, and rich information to the student experience. The video clips gave the professor a wonderful "stage" upon which to share topical concepts, experiences and stories, take students on virtual fieldtrips to energy-related sites and events across campus and the local region, and to give demonstrations of equipment and processes that students would generally have no access to otherwise. Again, students reacted very positively to the inclusion of such media, despite the technical challenge many students faced in trying to properly configure their browsers with the appropriate plugins to be able to run the movies and audio files.

II) Assessment & Feedback

Quizzing:
Another feature of student-centered design is the shift towards a wider array of assessments and feedback opportunities for students. In EGEE 101, we utilized numerous low-stakes quizzes, short reflective written assignments, and a few of the standard, high stakes exams. Computer based testing is commonly used to evaluate student ability. It is less commonly used as an enhanced learning opportunity. In this course the commercial software TestPilot was used both in an evaluation mode (40% of the exam score was based on multiple choice, select all that apply check boxes etc, the remainder from essay questions manually graded) and as an enhanced learning mode. For the enhanced learning mode the questions related to the lessons subject material were offered one question at a time with response specific immediate, often visual, feedback for every answer. A correct or incorrect answer was viewed as a learning opportunity thus informative feedback was provided. Analysis of graphs and calculations using random number generation were also used. The student was encouraged to take these quizzes as often as desired until the deadline (they tended to stop when achieving a 100 % grade). Many students would take the quiz 3 or 4 times to achieve the desired 100%. The question were drawn randomly from a larger question suite and reordered to make the sharing of answers more difficult. Each question was offered one at a time with immediate answer with specific feedback prior to receiving the next question. Eighty One percent of the students found this either useful (70 of the 179 respondents) or very useful (60/179) to their understanding and retaining the information.

Reflection Papers:
We also utilized variations of the "minute paper" to enhance student reflection both at the beginning and the end of each lesson. The initial reflection was titled a "wake up the brain." Submission of this reflection unlocked the lesson material. Consistent with constructivist learning theory, our expectation was to help students learn by building upon what they know[3]. Allowing reflection at the beginning of the lesson hopefully primes them for the material that follows. Questions such as "how will you decide which car to purchase?" were asked and the response graded looking for evidence of reflective thought. A paragraph answer was expected. This approach was not popular with the students. Forty-two percent considered it to be of no use in their learning of the material. However, just like a trip to the dentist, the authors hope the benefits outweigh the student resistance and will continue to utilize the approach. The reflection at the end of the lesson was more "useful" from the student perspective but only 35% considered the act of filling in a directed reflection ("Assuming you are environmentally responsible, now how do you decide on a vehicle purchase, what are the detrimental impacts of automobile transportation?") useful or very useful. It did however serve the purpose of ensuring the student accessed the material in a timely manner. The propensity for the student to access the material just before the deadlines was confirmed. Over 40% of the class attempted to complete a 2-week lesson on the date of the reflection deadline (this number may be artificially high as several students chose to print the material and also printed material for roommates and friends, however the number of students utilizing this approach was few in number (<10) based on correspondence to the instructor to explain limited online activity). This "just in time" studying approach was assumed not conducive to learning and retaining the information and mid-lesson reflections and quizzes were adopted for the remainder of the semester. The National Survey of Student

Engagement[4] revealed that many college students spend only about one hour preparing for each class--half as much time as teachers recommend. There was a strong relationship between GPA and time on task[4]. Teaching good study habits is part of the course learning objectives. It is recommended that students are assisted with weekly deadlines to prevent the "just in time" study approach prior to the first exam. Those students who seemed to have adopted this approach dropped the course following their very disappointing exam scores (approximately 8 students from a class size of 195).

III) Learning Communities & Communications:

Another feature of online environments that is both compelling and motivating for students and instructors alike is the increased opportunity to interact with each other and to create an evolving community of learners. Learning as a social experience gets great emphasis here, as does the sense of access that students and instructors feel they have to each other. Moreover, there is much research showing that participation among students in an online class of 200 students is likely to be significantly higher than participation between students in a resident classroom of the same size, and student/instructor interaction shows the same trend. This is not always true, of course, but even the singular experience gained from teaching EGEE 101 online this past year gave credence to this argument.
The benefits of learning communities are greatest when these spaces are utilized for collaboration, problem solving, debate, and discussions where individual experiences, attitudes, and opinions strengthen and enliven the experience for all.

IV) Student Management & Workflow

Another technique utilized to hopefully enrich retention information retention was the use of a faculty approved cheat sheet. During the TestPilot computational timed exams the student could have access to a single sheet of paper with their handwritten notes. An extreme example of the resulting sheet is shown in Figure 4. The role of the cheat sheet was to reduce the anxiety during the exam process and to introduce the student to a new study technique. The student who spent considerable time in the reflective preparation of the "cheat sheet" tended not to rely upon it as much those who did not (from observation of student behavior in the exam). Sixty percent of the students considered the use of the "cheat sheet" to be "very useful" (107/179). Several students commented that they "spent so much time on it (cheat sheet) that they did not need to use it (in the exam).

Figure 4. A "cheat sheet", a student written page, used during exams with the faculty blessing. The page is completely full of handwritten text.

Findings

Activity online is an interesting profile to monitor. The server logs record each time a web page is requested and the time of day. This approach does not include the class communications as that is within another series of servers. Half of the student activity (56%) was after the traditional workday of 8 AM to 5 PM (Figure 5). Mirroring the trend of late night activity on campus (early morning classes are not popular for the majority of students) only 10% of the online activity occurs within the morning hours (8:00 AM to 11:59 PM). This probably also reflects the student activity within other resident classes during the morning. Some 70% of the online activity occurs between 1:00 PM and 10:59 PM with a noticeable reduction in activity during dinnertime. About half of the online activity occurs between 6 PM and 4:59 AM. The bulk of the "after hours" activity (43 % of the total online activity) being between 6 PM and 1:00 AM. This was not unexpected as the advantage of an online course, from the student perspective, was accessing the class at a time convenient to their schedule and fitting in an online class within a hectic resident class schedule.

In calling for a more student-centered university, our President Graham Spanier has observed that "many of our students are creatures of the night … While we in higher education have designed a university to operate from eight to five, most students prefer noon to midnight. … [We must] think much more creatively and responsively about the needs of today's students[5]."

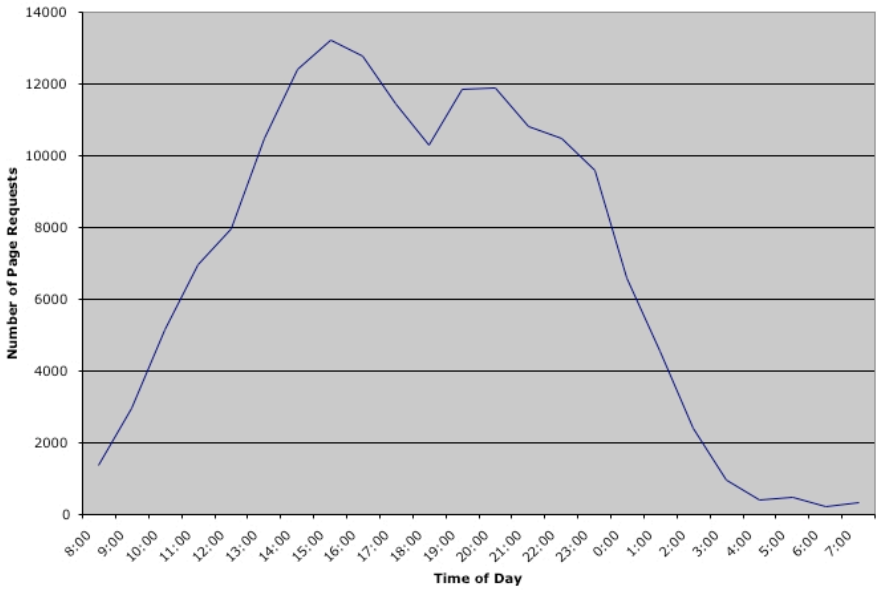

Figure 5. Profile of online activity (page requests) obtained from server logs for student activity at various times of the day averaged over the entire semester.

Common among the course feedback from students were: *"Being able to basically go at my own pace. I could have "class" at 3am if I wanted to, which I think is wonderful~ because I do my best work late at night."*

Student time on task during the day and some evenings are also constrained by part time employment. From 184 responces for the Spring 2003 class 52% indicated they would have a part time employment during the semester. Also 29 % of the respondents indicated they were unsure if they would be employed or not during the semester.

Daily activity is shown in Figure 6 Lessons began Saturday morning and ended on Friday night at 11:59 PM when homework submissions ended. Little activity occured on Saturdays (5%). It is probably that the football season might have influenced this low level. Sunday was more active with 14% of the total page requests. Monday had 11% of the activity, although these studetns tended to be the more organized and highly motivated students. Tuesday had 13% of the activity. Most of the students took exams on Tuesdays, the upper colomn in Figure 6 reflects this increase in page requests on Tuesday and on Monday (night). Wednesday has a spike in activity, presumably because of more students starting to look at the material. The bulk of the page requests came on Friday as the homework (reflection and TestPilot review quiz) was due. It is easy to criticise this behavior but the author notes that this paper's original draft was uploaded only minutes before the deadline.

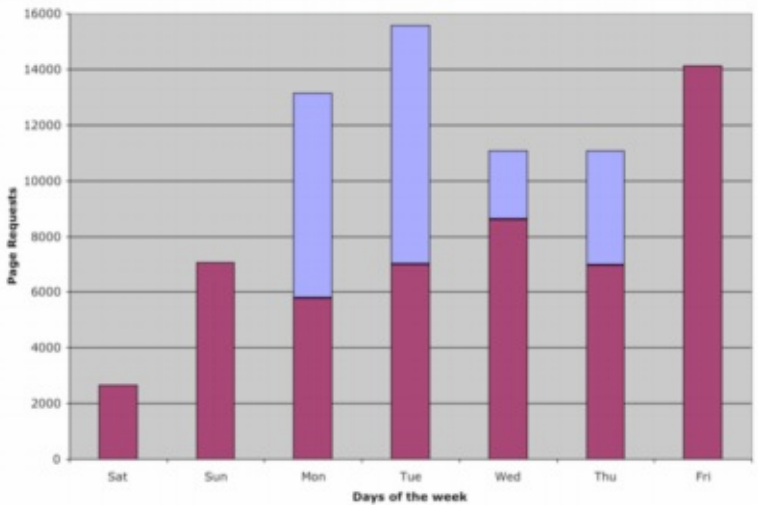

Figure 6. The daily activity (page requests) profile over the semester. The lower (red) columns represent student work activity related to weekly assignments, whereas the upper (blue) columns represent time spent preparing specifically for exams.

The time spent logged into the ANGEL system was also monitored for each student, as was the online activity. Students who are successful in the exams but are not spending in excess of 30 hours online were either very talented students or students who prefer to print the material and study from the printed pages. Surprisingly, the students indicated that on average they printed only 40 % of the material. Only 16% of the students indicated they printed 100 % of the course material. A greater percentage (26%) indicated they did not print any class material, which was an unexpected statistic. Course management systems enable instructors to monitor and enforce student engagement and participation, and to encourage effective study habits.

Overall the expectation was that utilizing the student computer interface, as a tool to enhance the learning process, would result in a learning experience at least as effective as the resident class. From the Student Rating of Teaching Effectiveness (SRTE), which is collected anonymously from a class survey conducted towards the end of the semester, the web-only delivery mechanism was equally as effective in "encouraging" students to think (Rate the instructor's skill in encouraging students to think) 5.5 on a scale of 1 to 7 (7 being the highest rating) which was slightly lower than the previous semesters resident version of the class which contained far fewer students. Out intention is to continue monitoring the class and report on the effectiveness of the learning environment and the activity of the students.

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