AC 2007-1483: THE USE OF A COURSE MANAGEMENT SYSTEM IN ENVIRONMENTAL ENGINEERING FOR THE EDUCATION OF THE GLOBAL CITIZEN

Lupita Montoya, Rensselaer Polytechnic Institute

Lupita D. Montoya is Assistant Professor of Environmental Engineering in the Civil and Environmental Engineering Department at Rensselaer Polytechnic Institute. She earned her BS degree in Engineering from California State University, Northridge, her MS in Mechanical Engineering and her PhD in Environmental Engineering from Stanford University.

Chris Moore, Rensselaer Polytechnic Institute

Chris S. Moore is a Course Developer in the Distributed Education and Multimedia Department at Rensselaer Polytechnic Institute. He has served as project leader for course support of distributed education courses, consultant to faculty on issues of technology integration, instructional design and content development, and researcher and evaluator for emerging instructional technologies. Chris earned a Master of Science degree in Curriculum Development and Instructional Technology in May, 2000 from the University at Albany. Chris has six years of experience in instructional design and integrating information technologies in support of teaching and learning.

The Use of a Course Management System in Environmental Engineering For the Education of the Global Citizen

Abstract

Educating the Global Citizen is the goal of many well-intentioned faculty in Engineering. How to merge that lofty goal into an often already packed course can be a challenge. As the need for exposure to "real world" issues becomes more urgent, instructors must find creative ways to make the connections between the theoretical and technical training that occurs in the classroom and issues and events occurring outside the classroom.

The use of course management systems could facilitate the process of educating the engineer of the future by providing multiple avenues for exploration. We, an Assistant Professor of Environmental Engineering and a Course Developer from the Distributed Education and Multimedia Department at our institution, worked closely to implement web-based tools and integrate aspects of social responsibility into an introductory course in Air Quality. For a year, we worked together to transform notes and resources into digital format and tested a number of tools within the available course management system (WebCT) at our institution.

The conversion of class notes to digital PowerPoint (PPT) format was undertaken to support a deliberate process-oriented pedagogy that required or strongly encouraged in-class note-taking (a mode of cognition or content interaction)[1]. Students only had pre-class access to partial/incomplete notes. The PPT design of in-class lecture notes was intended to support the flow of lecture content, facilitated insertion of problem-solving sequenced so students could immediately apply their knowledge, and allowed the instructor to interact with students more freely. Complete notes were unavailable for download or print - only for online review after class or before exams, thereby diminishing a typical faculty fear of posting course materials and losing class engagement. Fleeting availability of complete notes was used to promote student review in a more regular (weekly) fashion. In-class access to the web added content interaction during discussions that required information searching (e.g., to complete a table comparing CO_2 emissions from various countries). In-class and on-line discussions on the social implications of topics such as Greenhouse gases and the Kyoto Protocol were also pursued.

As part of the assessment process, students were given two entry surveys on the first day of class. One survey dealt only with issues regarding the use of WebCT and an on-line survey dealt with basic concepts related to the course content. Results from both surveys helped shape the format and the content of the course. Students were informed of the most salient issues emerging from these surveys and were asked for input at various points in the semester via on-line surveys and other formative assessments. A final survey assessed the progress on the general topics covered in the entry survey and the effectiveness of the use of the course management system.

Introduction

Introduction to Air Quality Control (ENVE 4330) is a required course for junior-level students in the Environmental Engineering program at our institute. As the only course about air pollution that our students receive within our ABET accredited BS program, it is a quantitative introduction to the engineering methods for the study of air quality. Topics covered in this course include: estimation procedures for air pollution emissions; indoor air quality problems, impacts and control strategies; sources, impacts and control strategies for greenhouse gases; dispersion modeling for point sources; pollutant acidification of lakes; urban source apportionment modeling; chemistry of stoichiometric and non-stoichiometric combustion; regulations for mobile and stationary pollution sources; control devices for motor vehicle and stationary source emissions; assessment methods for human exposure to air pollutants. The classroom facilities included a fully (wired and wireless) connected room with web-access for both students and lecturer and a computer projector. Lectures could be accessed directly from the course website during each lecture. Use of WebCT and other web-based tools have been used successfully in the past, particularly in distance education[2, 3]. In this case, the tool was used to enhance in-class and online learning as well as to monitor student performance and develop better assessment tools for engineering education. This approach attempts to address the recent "Call to the Nation" regarding the research agenda for engineering education[4,5].

Each topic was treated individually and access to online materials were monitored to determine any correlation between access rates and demonstrated proficiency in exams. Analyses for specific topics were conducted and are presented here for illustration of the method. Overall, we saw that students who used the on-line resources, particularly the complete note sets for a given topic, scored consistently higher than those who did not access these resources. In-class problem solving sessions were also incorporated in this course, featuring active participation of students on the solution presentation. Analysis of the data showed that this mode of teaching in combination with on-line access to problem solutions was particularly effective for this cohort of students.

In addition to the technical content of this course, the instructor endeavored to incorporate discussions on the social and policy implications of the various topics covered. One such topic was greenhouse gases and related discussions on global warming and the Kyoto Protocol. In order to assess the general knowledge level of these students regarding some of these topics, entrance and exit surveys were conducted.

This pilot study offers insights into the teaching strategies and methods used. We consider our findings to be preliminary and of a nature to provide formative analysis for future development of the techniques presented.

Course Format

The course schedule provided two class sessions per week throughout a fifteen-week semester. In each class session, lecture was provided on the scheduled topic. One overarching pedagogic principle was that active note taking during class would be encouraged. Although lecture materials, including all course concepts, equations, example problems and solutions, and

supplementary resources were displayed during class in the form of PowerPoint slides displayed through the computer projector, students were provided with only partial notes prior to class. In this way, students were encouraged to write personal notes, utilizing the visual cues of the instructor's complete notes as a guide. This method of supporting student note taking by providing partial notes is supported in the literature. Robinson, et al. found that students using partial notes (graphic organizers) to guide them in their note taking performed better on examinations and quizzes than did those students who were provided with complete notes[6]. Austin, Lee, and Carr found that the use of partial notes in conjunction with instructor note slides presented during lectures, resulted in more complete note taking by students[7]. Kiewra concluded that note taking on partial outlines leads to higher achievement than does standard note taking[8]. Further, students who review their own notes added to the partial notes, as well as review the complete notes provided by the instructor, perform better than those who review only their own notes or only the complete notes[9].

A total of 21 general topics were covered in this course, spanning from indoor, to urban and global scale issues in air quality. Each student received a packet of "incomplete notes" at the beginning of each lecture as a base from which to work. The instructor would then proceed with the lecture starting from these same sets of incomplete notes using PPT presentations. Slides were designed such that emerging course material would appear in a different color than the partial notes content so that students would observe a visual cue to add personal notes to their copies of the partial notes. The emerging content was sequenced according to the lecture topic agenda and time was allocated for students to complete their notes in-class. Each topic was fully covered in class and additional reading materials were available at our course website as a resource. In addition, the complete notes were made available for on-line review only on the course website, and only for a limited time period.

Our intent was to encourage in-class engagement, note taking, problem solving, and discussion. Therefore, to discourage students from relying solely on the complete notes and/or be tempted to reduce their class attendance in favor of acquiring the course content at their leisure, we prevented the downloading or printing of the complete notes and restricted the accessibility of the notes. To achieve this goal, we relied on existing standard software tools to reformat the lecture slides and utilized the "conditional release" feature of our institute's Learning Management System – WebCT CE 6/Blackboard (LMS)[10]. The complete versions of these notes were made available for review, but not download, on our course website. These complete notes were only available for one week after each class session. This process was meant to motivate students to access the material soon after each lecture topic was covered so as to maximize comprehension retention rates.

We converted the instructor's PowerPoint lecture slides (the complete notes) into Adobe Flash (SWF)[11] format and delivered them within HTML web documents. This procedure offered both a method of providing fairly large files on the web in an efficient way (SWF) and the capability of using web programming to restrict copying, printing, and downloading that was the most feasible given the software at our disposal. The process of converting PowerPoint slides to Flash included adding ActionScript coding that disabled the Flash Player print menu. Additionally, we embedded the Flash content in HTML pages that included CSS code that disabled copy/paste of the content within the document. All HTML files containing the Flash notes and security coding

were uploaded to the LMS. Using the "conditional release" functionality within the LMS environment, we limited student access to the complete notes to the roughly seven-day period immediately following each corresponding class session. Additional access to all of the complete notes was granted approximately two weeks prior to each quiz or examination to allow additional review.

In addition to the two (2) examinations and the final, an early quiz was administered. This quiz had a hybrid format, including an on-line portion and a problem-solving portion, both completed in class. This exercise proved a bit problematic primarily due to limitations posed by the on-line portion. Improvements can easily be implemented on this regard, particularly those related to language or word choices. Similar quizzes are being considered for other stages in the course and will be used as formative assessments and not as evaluation tools. Students were also offered the opportunity to write an extra-credit paper on a topic closely related to those covered in class. This option was presented as an alternative for those students who had a personal interest in a topic or needed some extra help in reaching a desired grade. It was also a way to assist those students who suffer of anxiety during exams.

Analysis of student access to content:

One of the goals for the new course format, was to be able to assess whether online access to course materials would aid in the learning process. Using WebCT as our course management system allowed us to pursue this goal. A set of complete notes was made accessible for a period of one week right after each corresponding lecture. These notes were also made available again two weeks prior to each of the examinations. The number of access sessions as well as the time for each session was automatically recorded by WebCT for each individual student. These data were then used to correlate student performance to the use of online materials. The summary of online activity and general statistics for the class were generated and are shown in Table 1. Noteworthy are the facts that the most active day was the day of the final exam (which took place at night, while the least active day was at the beginning of the semester). Similarly, the average number of user-sessions per day value was higher for weekdays (12) than for weekends (8). It is also possible to access individual student activity information including the dates and times that individual files were viewed, as well as the time spent in each file. This individualized information can be used by the instructor to encourage those students not performing well in class. Today's students are often driven by statistics and this tool may be sufficient to provide the needed motivation for some of them to increase their activity rate and improve their performance.

Statistic	Value
Total user sessions:	1343
Average user session length:	0:11:10
Average user sessions per day:	12
Average user sessions per day on weekdays:	13
Average user sessions per day on weekends:	8
Most active day:	14-Dec-06
Least active day:	26-Aug-06
Most active hour of the day:	2:00 PM - 3:00 PM

Least active hour of the day:	3:00 AM - 4:00 AM

Table 1. Summary of Activity Report for the Course.

More detailed analyses were performed for specific topics incorporating on-line access data and performance in topic-related problems in exams.

Example 1: Progression of Accessibility

Combustion Stoichiometry (Topic 15) was covered in Exam 1 as well as in the Final. In Exam 1, the average for this problem was 77.3%. Although the score appears quite reasonable, further analysis showed some interesting detail that could be leveraged in the future. On this given problem, the top 52% of students scored 87% or better (average 94%); out of this group, 46% of them accessed the complete notes prior to the midterm. On the contrary, the bottom 48% of students scored 80% or lower (average 59%); out of this group, 25% accessed the complete notes prior to the exam. This comparison is presented graphically in Figure 1. The top set of bars represents the % of students who accessed the notes online. The middle set of bars represents the lowest score achieved within each group (i.e., bottom 48% or top 52%). The bottom set of bars represent the average percent performance for each group.

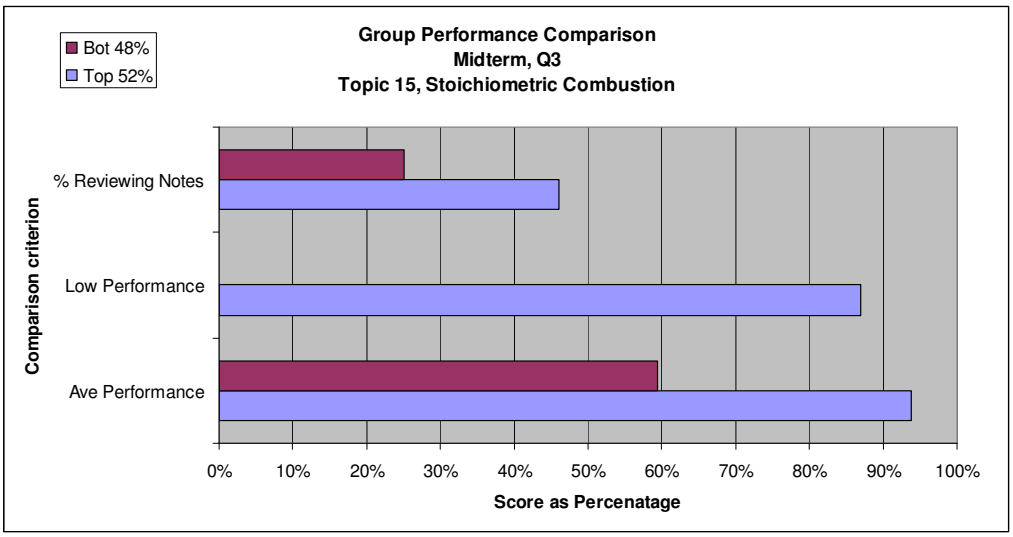

Figure 1. Group Performance Comparison for Problem 3 in Exam 1.

The rate of access of course notes by the top performing group increased significantly as the semester progressed (by about 15%) while access rates for the lower performing group increased only marginally. The topic of combustion was also covered in the final exam, and we looked at the student performance in the related problem as well. The results of this analysis are shown in Figure 2. The labels are similar to those in Figure 1. In this case, the top 40% of students scored 80% or better (average 88%) on the Combustion problem; out of this group, 60% of them accessed the complete notes at some time in the semester. On the other hand, the bottom 44% of the students scored 67% (average 42%) or lower on this problem; out of this group, only 27%

accessed the complete notes at some time.

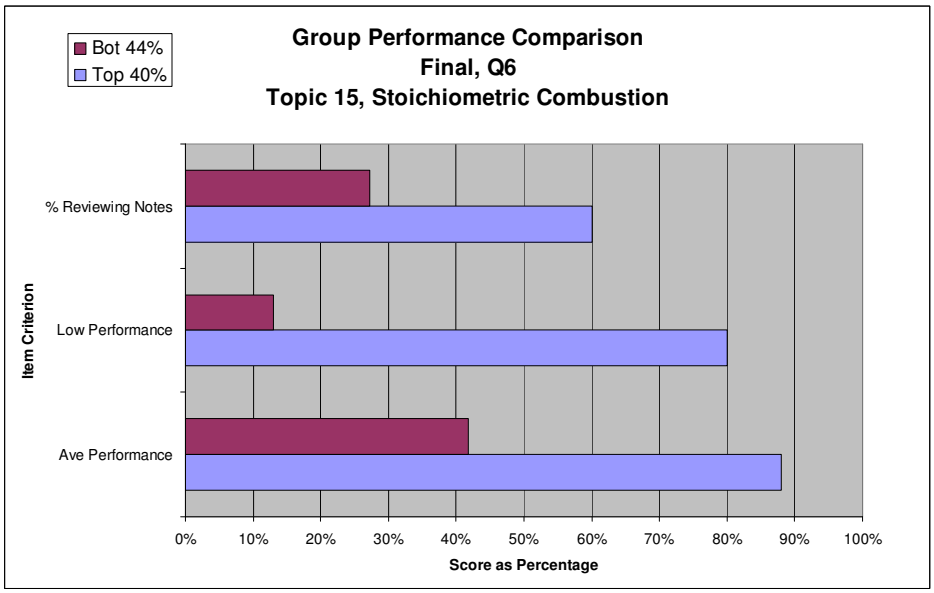

Figure 2. Group Performance Comparison for Problem 6 in Final Exam.

Example 2: Combined Utilization of Topics

This problem was included in exam 2 and it addressed three topics: Indoor Pollutant Control Strategies (Topics 4 and 5) and Control Strategies for Particulates (Topic 18); data analysis includes access data for all topics. Graphical results are presented in Figure 3. The average score for this problem was 74.3%. For this problem, the top performing 48% of students scored 81% or better (average 94%); 67% of this group accessed the complete notes prior to the midterm. On the other hand, the bottom performing 52% of students scored 75% or lower (average 56%); from this group, only 31% of the students accessed the complete notes prior to the midterm.

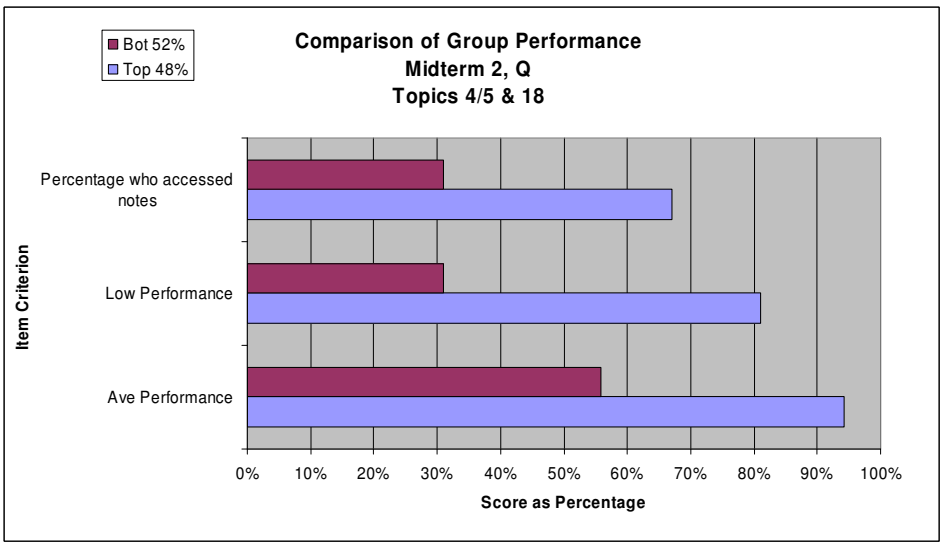

Figure 3. Group Performance Comparison for Problem 4 in Exam 2.

Since percentages of students accessing the complete notes increased between exam 1 and exam 2 for each of the groupings, it is possible that students were learning to appreciate and use the extra resources available to them. Although Example 2 includes access to topics 4 and 5 complete notes, which were delivered and available much earlier in the semester (prior to midterm 1), views of topic 18 complete notes, which were delivered and available later in the semester, account for 67% of the access sessions for the topics related to this problem (including all students).

Example 3 – In-class Problem-solving and On-line Access to Solutions

The topic of Management of Ambient Air Quality (Topic 20) was covered toward the end of the semester and was included in the Final exam. In addition to the previously discussed on-line resources, students also did an in-class practice problem before the exam. Solutions to this practice problem were also posted on our website. The average score for this problem was 91%. It seemed that this combination of approaches helped significantly; consequently, in future classes, this combination will be further explored.

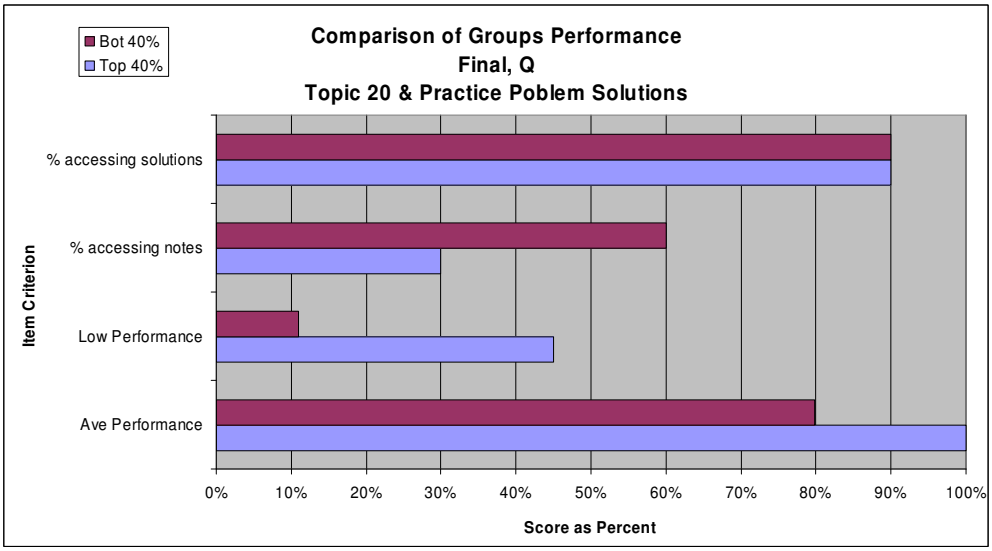

Figure 4. Comparison of Group Performance for Problem 3 in Final.

It should be noted, however, that lecture on Topic 20 was delivered fairly recently before the final and the practice problem regarding this topic was covered in class the week before the final. Additionally, solutions to these practice problems were provided online before the final and students had three days prior to the final to review them. The performance on this problem (3) was markedly better than on the two other topics in this analysis. Results of this analysis are shown in Figure 4. It is worth noting that all but three students (88% of the class) accessed the lecture notes and/or the practice problem solutions (12 accessed the lecture notes, and 19 accessed the problem solutions - 9 accessed both) online prior to the final.

Preliminary analysis of Examples 1 and 2 indicate a common result – students who performed better on the exam problems accessed the complete notes for corresponding topics at higher rates than did students who performed at lower levels on the same problems. Additionally, we observe the possibility that students may be accessing online complete notes at increasing rates as the semester proceeds. Analysis of Example 3 presents a different scenario. We find here a benefit to presenting practice problems in class prior to exams on which the problems will be given. Additionally, since most of the students in the course performed quite well on the corresponding exam problem and the vast majority also reviewed the practice problem solutions online prior to the exam, it appears that providing access to problem solutions online is beneficial to student exam performance. We see an inconsistency in Example 3 in that students who performed to a higher degree on the exam problem, accessed the corresponding notes at lower rates than did those students who performed to a lower degree on the same problem. The analysis of this result is confounded by the fact that the topic under analysis is being delivered in a variety of ways and in multiple instances. In this way it is different than Examples 1 and 2. Further analysis will be needed to examine more fully the impact of online review of complete notes on student exam performance.

Educating the Global Citizen

In addition to finding an optimum delivery mode for the technical content, in-class and on-line discussions on the social and policy implications of some related topics were integrated into this course. For example, a timely opportunity for a discussion on global warming and the Kyoto Protocol came up during the semester. Soon after the lecture on Greenhouse gases was delivered, students engaged in an in-class discussion of the Kyoto Protocol. Based on the entry survey, it was apparent that most students were not familiar with this topic. The in-class discussion involved accessing material from the web to complete a comparison of data about per capita CO_2 emissions for developing versus developed countries. Students actively participated in this exercise and seemed to enjoy it. Following the in-class discussion, students were required to post answers to related questions on the on-line discussion board for this class. The related question was: "Do you believe in Global Warming and why?" In addition to the student responses, responses from faculty within and outside our institute were also posted. These responses were only posted after students had submitted their initial responses. Among those faculty submitting opinions, there were experts in Heat Transfer, Aerosols and Environmental Science. Such discussions will be further explored in future courses.

Linking the theoretical training students receive in class to applications in the "real world" is an effective way to motivate students to appreciate the course content. Knowledge and application of topics that may affect policy is an important step in making a course material relevant. In this case, bringing expert practitioners to the class to imbue course content with real world affairs and technological developments could be quite useful. In this course, we brought in a combustion researcher employed by the State of New York and whose research findings may have implications on the auto emissions policies that these students may see in the future. Based on the comments from the students, this opportunity was appreciated and at least four students engaged further learning in this topic by writing an optional extra-credit paper on a related topic. The guest expert offered guidance to these students. Although no systematic evaluation of these

components was conducted in this study, we will pursue it in the future since we plan to continue these initiatives. As a preliminary indication that these efforts worked, we looked at the topics selected by students who chose to write an extra-credit paper. Sixty eight percent of all the students in this class chose to write an extra credit (optional) paper. Of those students, 82% chose a topic related to our in-class and on-line discussions or guest speaker presentations.

Entrance and Exit Surveys

In order to assess the general knowledge level of these students regarding some specific topics related to air quality, entrance and exit surveys were conducted. Simple multiple choice or true false questions were presented using the on-line quiz tool of WebCT. Figure 5 shows the percent changes in the correct responses to the Entrance and the Exit Surveys.

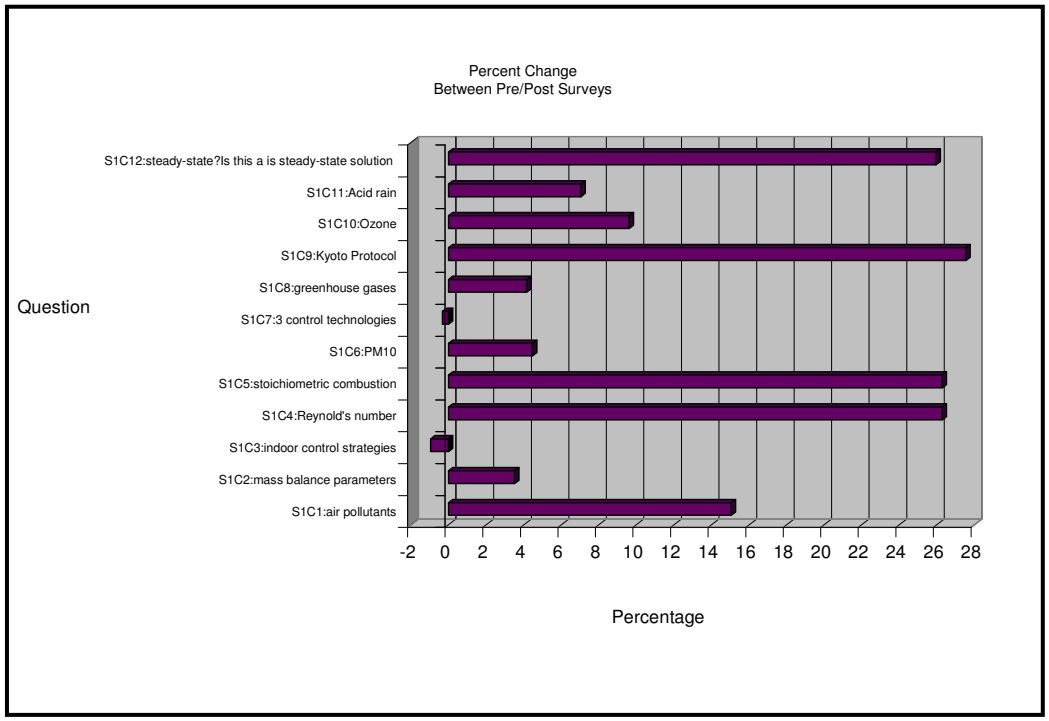

Figure 5. Percent change between Entrance and Exit Surveys.

Some survey questions directly addressed topics that would be covered in the course, while other questions addressed general knowledge indirectly related to the course or knowledge considered as expected background. An example of the latter question type was the question "What does the Kyoto Protocol deal with?" Example of choices given included: a) Substances that deplete the ozone layer; b) Climate change; 3) Proliferation of nuclear weapons; 4) Use of biological weapons; 5) None of the above. Results from these surveys showed a significant improvement from 36% to 65% correct responses by the end of the course. It is possible that even though the Kyoto Protocol was not part of the course material, the in-class and on-line discussions revolving around this topic were responsible for this increase. Including even a small statement about this

topic within the class notes, combined with these discussions may be sufficient to reach a more acceptable correct response rate (>90%).

An example of the former question type was the True of False question: "Is the following a steady-state solution?" Student correct responses for this question changed from 68% to 91% by the end of the semester. Since this course covers mass balances extensively during the first part of the semester, students were often reminded or asked to identify whether a solution depicted a steady or non-steady state. These simple questions could easily be inserted within formative assessment tools throughout the semester to reinforce this concept.

Discussion and Conclusions

Although we consider this to be a preliminary or pilot study, results obtained from this experience will be utilized to improve this course and enhance the learning environment for our future students. The following conclusions constitute a set of recommendations for us to follow on our next iteration of this course.

Digitizing notes allowed for flexibility in lecture planning, ease of incorporating guest lecturers, and opened up the schedule/lectures for additional problem solving, including problems relating to "real world" scenarios. In particular, it offered the opportunity for in-class and online discussions on the social and/or political implications of topics such as the Kyoto Protocol, which were not formally part of the lectures. Incomplete notes enhanced the learning experience by providing guidance on the note-taking process, a notorious shortcoming of today's students. Accessibility online to the full notes, but on a limited fleeting timeframe (and not downloadable) was meant to force students to plan ahead and to actively write notes. Results showed that accessing these resources, on average, improved student performance in exams. Overall, we saw that higher rates of access to complete notes online correlated with better performance in exams. We plan to continue to use partial notes combined with online access to complete notes in the future.

Performance on the final, problem 6 (combustion) may have been impaired by faulty crib notes. It is also possible that lack of review of the complete notes earlier in the semester contributed to weaker comprehension of the core concepts of the topic and this was in turn reflected in incomplete or inaccurate crib notes. Adding a "checklist" of sorts for students to use in preparing their crib notes may be useful in the future.

We found that the combination of partial notes, in-class problem solving exercises and access to complete notes and solutions to practice problems yielded the best results. We intend to incorporate a more "studio" style format in our course by including more in-class problem solving sessions, encouraging regular and earlier review of complete notes, and employing formative assessments in the future. Formative assessments will be particularly useful for reviewing the most important concepts in a given chapter and cementing this knowledge before an examination. This process will be one mechanism through which we intend to improve the negative results observed in Figure 5.

Educating the global citizen posed a specific challenge that was tackled on several fronts.

Integrating in-class and online discussions on topics such as the Kyoto Protocol and Global Warming seemed to motivate students to become more informed on current events related to the environment. Bringing outside lecturers with expertise in areas covered in class and whose work may have relevance in future policies for our state also seems to have a positive effect. We interpret that as a very positive sign and we intend to continue these efforts and incorporate more systematic analyses of these initiatives. In addition, the instructor intends to integrate input from experts in Cognitive Science within our institute to maximize the effectiveness of these exercises.

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