The Benefits of Using Web-Based Enhancements in an Environmental Chemistry Class

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Abstract: Four semesters of student evaluations of an environmental chemistry class have been analyzed for differences that can be attributed to Web-based enhancements. The enhancements included Web-based lecture notes, reading and problem assignments, bookmark files, and videotaped lectures. We developed these materials as part of a larger project to provide university-level technical courses over the Internet. Student perceptions of the course improved significantly (α = 0.10) after adding Web-based enhancements. Student's opinion of the instructor improved, but the change is not significant at the 90% confidence level. The student responses to "Was the course challenging?" "Was my interest stimulated?" and "Was the instructor concerned?" were unchanged in the two groups of students. Drop rates were unchanged between the two student groups. The grade-average was nearly identical for the two student groups (82.9% vs. 83.5%), but the grade-distribution changed significantly. The percentage of A's decreased slightly when Web-based enhancements were added, but the number of B's increased from 22% to 40%. The percentage of C's, D's and F's decreased for the students with access to Web-based enhancements. These results indicate that Web-based materials helped weaker students improve their performance and, therefore, their opinion of the class and of the instructor was more favorable.

Introduction

Higher education has recently experienced an increase in the number of chemistry courses that to some degree incorporate student use of the Web [1–11]. As Web-enhanced courses and tutorials are developed and offered to students, it becomes necessary to carefully evaluate their effectiveness. Although there have been many articles published about Web enhancements [1–11], few attempt to examine whether these enhancements contributed to overall student satisfaction or improved student performance. Holme [1] used Web-based writing assignments in an introductory chemistry class and found a weak correlation between scores on Web assignments and test scores. Student surveys indicated that the Web writing assignments helped them "learn much more" about the topic on which the assignment was based. Parrill and Gervay [2] developed a series of interactive stereochemistry tutorials, which were made available on the Web. Their evaluations of the project indicated that students enjoyed working with the tutorials and possibly spent more time studying because they were available. Lui et al. [3] offered a chemistry curriculum/instruction course via the Web that, despite a mere 50% completion rate, was favored by students. Tissue et al. [4] designed, used, and evaluated Web-based prelaboratory exercises. They found that these exercises were better for increasing conceptual understanding than for preparing the students for the actual laboratory work. Weaver [5] developed a Web site covering the subject of acids and bases for use as a supplement to the General Chemistry course. Surveys showed that students who used the site to help them with their problem areas were able to achieve a modest grade improvement over their performance on other exams.

We added Web enhancements to an upper-division environmental chemistry course (CHM 440 sylabus available in 43rf1897.pdf). These enhancements include posted lecture notes that contain reading assignments, homework assignments, and links to sites with valuable supporting information. Video clips (viewed using streaming video), graphics images, and audio clips were added where appropriate. In addition, examinations from past years were also posted to the site. We compared two semesters of the course before Web enhancements to two semesters of the same course with the same instructor after Web-based enhancements. By comparing the end-of-semester evaluations, we found that Web enhancements of the environmental chemistry class improved students' overall estimate of the course and the overall estimate of the instructor. Students indicated on an end-of-semester questionnaire that they found the availability of lecture notes and e-mail messages containing homework and reading assignments beneficial. Furthermore, by comparing course grades from four different semesters, we found that Web enhancements improved the performance of weaker students.

Background

Northern Arizona University (NAU) has offered an environmental chemistry class, based on the textbook *Environmental Chemistry* by Stanley Manahan, for the past 25 years. Approximately 40 students take the course each spring semester, and the student population consists of equal numbers of science (chemistry, geology, biology and environmental science) and environmental engineering students. We chose environmental chemistry as the first of 15 classes to be developed for Internet delivery to in-place professionals. Environmental chemistry was selected because of the large body of supporting materials readily available and because of our successful history with this class. The URL for our Web-based program is http://jan.ucc.nau.edu /~doetqp-p/doetqp/ and the URL for the environmental chemistry class is http://jan.ucc.nau.edu/doetqp/courses/env440/env440_2/index.htm.

Internet delivered courses must provide the student with an equivalent learning experience to the traditional on-campus class. Videotaped lectures were selected for this program because they provide a means of delivering content in a format very similar to classroom lectures, but do not suffer the time constraints of satellite delivery or videoconferencing. Working professionals and in-place workers prefer videotaped lectures because they are asynchronous and, therefore, offer learning on demand.

Lecture notes provided ahead of time assist the student in several ways. An obvious advantage is the opportunity to preview lecture material before class. We recommend to both the distance-learning students and to the on-campus students that they print the lecture notes before watching or attending the lecture. They are then free to follow the discussion without worrying about taking notes. Chemical formulas and structures are in the lecture notes, and students don't have to copy this complex information on the fly.

Our Web-based lecture notes contain reading assignments for the lecture, homework assignments, and links to sites that contain valuable supporting information. In some cases, we have added video clips (viewed using streaming video), graphics images, and audio clips to embellish the Web site. When constructed in this fashion, Web-based lecture notes become interactive and provide a more dynamic learning experience.

One last enhancement that has been very well received by students is the posting of the previous year's examinations. Students can print these examinations and work the problems as though they were taking the actual test. Finally, a complete set of lecture videos was placed on reserve in the library for the on-campus students.

Characteristics of the Student Population

Seventy-seven students enrolled in CHM 440 in the two semesters before Web-based enhancements were available and 84 students enrolled in the two semesters after adding the enhancements. Composition of the before and after groups was constant with 15% graduate students, 45% seniors, and 40% juniors. All 161 students listed either a science or engineering field as a major; approximately 30% of the students were engineering students.

Computer literacy of the "after" students was measured by asking students questions about their computer usage habits. Eighty-six percent of this student group agreed with the statement that they had ready access to a computer. The majority of the students accessed the Internet using student computer laboratories or the campus library. A small, unknown percentage of students accessed the Internet using their own computers.

Seventy-one percent of the "after" students claimed they used the Internet more than three hours a week for school purposes. Only 6% of these students did not use the Internet for schoolwork.

Discussion

The goal of this project was to determine whether or not Web-based enhancements had a positive impact on students' success and their perceptions of the instructor and of the course. We found that students perceive Web-based enhancements as beneficial, that students developed a more positive attitude about the course and the instructor, and that the performance of weaker students improved as a result of the Web-based enhancements. Each of these benefits of Web-based enhancements is discussed below.

Students' Perception of Web-based Enhancements

During the last week of the semester, we asked students in the Web-enhanced classes to answer specific questions about the Web-based enhancements. The evaluation form consisted of 14 questions, each with 5 possible responses: (1) strongly agree, (2) moderately agree, (3) agree, (4) disagree, and (5) strongly disagree.

Ninety-two percent of the students agreed (sum of responses 1, 2, and 3) with the statement that lecture notes available on the Internet were beneficial. Ninety-five percent of the students agreed that being able to download the lecture notes before class was beneficial; 65% of the students strongly agreed with this statement. E-mail messages containing homework and reading assignments were considered beneficial by 86% of the students.

Help sessions, where the instructor answers questions and works homework problems, are offered for most of our undergraduate classes. Help sessions have traditionally been popular with NAU students. We anticipated that Web-based enhancements would decrease interest and attendance in help sessions, but were surprised to learn that 97% of the students agreed that help sessions were still beneficial (88% strongly agreed). Even though the Web-based enhancements were perceived as a benefit, they apparently would not substitute for or replace help sessions.

Changes in Student Attitudes

Northern Arizona University requires that each course be evaluated by students near semester's end. The evaluation instrument consists of nine questions that permit responses from 1 through 5, and all classes in the college are evaluated with the same evaluation form. Five is the most favorable response and 1 is the least favorable response. The results are compiled by the Dean's office, and summaries are returned to the instructor the following semester. The summary lists the average response for each question along with the college average. Changes in the student responses to five questions from the college evaluation were used to quantify changes in student attitudes.

Table 1 summarizes student responses from four semesters of teaching CHM 440. The "before" columns are the combined student responses from the two semesters the course was taught before Web-based enhancements were made available. The "after" columns are the combined student responses from the two semesters the course was taught after Web-based enhancements were added to the course.

Responses to 3 questions on the course evaluation showed no significant change in student attitudes between the "before" and "after" groups. No change in student attitudes occurred for the following questions: (1) "Was the Instructor Concerned?" (2) "Was my interest stimulated?" and (3) "Was the course challenging?" The two responses that showed improvement in

Table 1. Class Evaluation Results Showing the Effect of Adding Web-Based Enhancements to NAU's Environmental Chemistry Class

	Before			After		
Question	Mean	n	s2	Mean	n	s2
Was instructor concerned?	4.52	60	0.525	4.50	58	0.465
Was my interest stimulated?	4.20	60	0.875	4.24	58	0.818
Was the course challenging?	4.08	60	0.823	4.12	58	0.775
Estimate of the course	3.92	64	1.280	4.24	58	0.642
Estimate of the instructor	4.27	60	0.741	4.45	58	0.532

Table 2. Grade Distributions Showing the Effect Web-Based Enhancements Had on Student Performance in NAU's Environmental Chemistry Class

	Before	After	Before	After
Final grade of A	28	36.36%	25	29.76%
Final grade of B	17	22.08%	34	40.48%
Final grade of C	19	24.68%	13	15.48%
Final grade of D	4	5.19%	2	2.38%
Final grade of F	1	1.30%	0	0%
Withdrawal	8	10.39%	10	11.90%

student attitudes were "overall estimate of the course" (3.92 versus 4.24) and "overall estimate of the instructor" (4.27 vs. 4.45).

Data from this type of questionnaire are not normally distributed and, therefore, requires the use of nonparametric procedures to evaluate significance [12, 13]. The raw student responses from the "estimate of the course" and "estimate of the instructor" questions were tested using the Mann-Whitney test to evaluate significance of the observed changes [14]. The median response of the "after" group was compared with the median response of the "before" group for the questions dealing with "estimate of the course" and "estimate of the instructor." The calculated test statistic comparing the "before" and "after" groups on the "estimate of the course" question, is T_1 = 1.3588 ($T_{0.10(1),\ 64,\ 58}$ = 1.2816). This shows a significant increase in the median response for the "after" group at a probability level of 0.0871. The calculated test statistic for the "estimate of the instructor" question is T_1 = 1.174 ($T_{0.10(1),\ 60,\ 58}$ = 1.2816), with a probability level of 0.121. Therefore, the increase in the median response to the "estimate of the instructor" question is not significant at the 90% confidence level. Differences in the median responses for the other questions were not tested because the differences were smaller than that observed for the "estimate of instructor."

Changes in Student Performance

We compared the grades of the two student groups to see if Web-based enhancements had any effect on performance. The average score of the "before" students was 82.9%, while the "after" students averaged 83.5%, indicating no change in the overall student performance between the two groups.

Examination of the grade distributions shows that the percentage of A's decreased slightly (36.36% versus 29.76%) with Web-based enhancements; however, the percentage of B's increased from 22% to 40%, and the percentage of C's, D's, and F's decreased. The percentage of students who dropped the course after the first week of the semester was essentially unchanged (10.39% versus 11.90%). A breakdown of the grade distributions is given in Table 2.

Student Use of Web-based Enhancements

We asked CHM 440 students several questions about their use of Web-based enhancements during the most recent offering of this class. Eighty-eight percent of the students responding felt that Web-based enhancements *significantly* helped them master the subject material in this class. Students accessed the Web-based material from computers at home, campus computer laboratories, computers in the campus library, and from computers owned by friends. This survey also demonstrated that

students accessed the Web-based materials at all times of the day or night with no clear preference for one time period over another.

When asked an open-ended question about Web-based enhancements; students responded favorably. One individual wrote, "The class notes being on the Web helped because I could print them up and really understand what was being said in lecture instead of aimlessly taking notes." Another student wrote, "Previous exams and homework assignments allowed me to use it at my own pace. Lecture notes allowed me to be ready for a lecture and pay attention in class." The comments of a third student were "The extra Web sites added more insights to the different topics covered in lecture." When asked for suggestions for improvement to the Web-based material, one student commented, "It ain't broke! Seriously, it's easy to use and interesting to explore. I would like to see this type of enhancement in other classes."

Conclusions

Students with access to Web-based class notes, homework and reading assignments, and videotaped lectures believe these enhancements are valuable and contribute to the learning experience. Overall student performance does not change with access to Web-based enhancements, but the students' perception of the class does improve significantly. A small improvement in the student's perception of the instructor was also noted.

Although the overall performance was unchanged with Web-based enhancements, the number of C's, D's and F's decreased. Because the "after" group contained a smaller percentage of low grades, we conclude that the weaker

students did better when Web-based enhancements were available. By making lecture notes, reading and homework assignments, and videotaped lectures available 24 hours a day, we provided opportunities for slower learners to study at their own pace. The improved performance of the weaker students may explain why class evaluations were more favorable for "estimate of the instructor" and "estimate of the class" questions. Simply stated, successful students feel better about their instructor and about their learning experience.

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