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Computers in Chemistry

Evolving Towards Meaningful Web Assignments

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In this paper we describe a series of web assignments carried out in large lecture, introductory chemistry courses. Our intent is to share the path by which assessment of student attitudes about these assignments has led to a relatively useful assignment after several attempts. At each step in our development we have used student surveys to refine our assignments and show how these refinements lead to positive outcomes in terms of both student attitudes and reported learning.

Our intent was to show, through surveys of student's attitudes, how various assignments influence them.

Introduction

The emergence of the World Wide Web as an educational force presents both challenges and opportunities to educators. For science education in particular, the challenge of how to use the web merits formal discussion. The utility of computer automated, interactive tutorials delivered over the web has been suggested [1] and studied [2]. There is likely to be a place

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for such efforts in chemistry education, but they do not truly access the full value of the web, its vast, searchable database of information. Some efforts in using the web have been reported, however. Bungay and Kuchinski [3] describe their usage in Chemical Engineering courses and McGowan and Sendall [4] discuss the web as tool for use throughout the chemistry curriculum, a tool that may be particularly important to women students. Finally, Lustich [5] describes a chemistry assignment where students evaluate chemistry based sites. Each of these reports provides some useful insight into ways to use the web in chemistry, but none describe the techniques presented here.

In introductory chemistry courses the availability of information is complicated by several forces. First, students' capacity to digest the information is in many ways limited [6] and not only because they are novices in science. Second, the lack of control concerning the accuracy of the information [7] means that students who are constructing meaning based on what they find on the web may be building on poor foundations. Third, while the web has become culturally pervasive, in some settings access issues remain important [8]. Thus, commuter campuses may address web-based learning differently than residential campuses. Finally, many introductory courses are taught in large lecture sections, so the issue of student accountability and grading also affects the nature of web-based assignments.

Like many educators across the country [9], we have faced these challenges of using the web in course assignments, and here we report on our evolution. Initial attempts to include the web were essentially designed to introduce the medium. As we became more aware of student attitudes and abilities, our assignments became ones that embrace the sprawling lunacy of the information available and that force students to be discerning about what they read. Our assignments also include writing components, which further enhances the outcomes of the web usage. Our presentation is organized according to the stages of development we have used for our assignments. We also conclude with more general impressions of the role the web can play in chemistry education.

Initial Steps

When we first introduced web assignments, our intent was to force students to acknowledge the existence of the resource rather than truly exploit it. Once introduced to the web, we reasoned, most students will explore it and then add it to their learning

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repertoire. Thus, in a course for non-science majors, we began by requiring that students (a) look up web sites and (b) report URLs by email to their teaching assistant (TA). There was no writing requirement and the grading burden was modest and well-defined. TAs were only to check that the submitted site was germane to the assigned topic and that no other student in the laboratory section had already submitted the same site (included to encourage individual development of web skills). Five such assignments were included during the duration of the course and successful completion of the assignments would earn the student 1/6 of the available points in the course.

This assignment appeared to have accomplished its modest objectives. First, students largely did learn to use the web. Anecdotal comments from students suggested that they valued being "forced" to learn about it. During the standard end of course evaluation, students were encouraged to write about their perception of the web assignments (though no formal questions were asked). Of 110 evaluations collected, 69 included written comments about the web assignments. We coded these written comments based on similarity of wording; thus, descriptions such as "great," "excellent," and "best" were considered equivalent for analysis purposes. Within such a coding scheme, Figure 1 provides a summary of student reaction to this modest web assignment. Clearly, students affected enough to make written comments were largely positively affected. While the reasons for being positively influenced varied, the most common category was improved computing skills. Relatively few noted that the assignments enhanced course-specific learning, and this revelation began our move towards using the web rather than introducing the web. Moreover, several students noted rather cynically that the assignment was too easy and didn't even require them to read the web sites they submitted. For these reasons we chose to enhance the assignment.

Incremental Improvements

In our first revision of the web assignments, we initiated a quite modest writing expectation. The number of assignments was reduced to four during the semester, and in addition to finding sites pertinent to a particular issue, students had to describe the information therein contained in a few sentences. These assignments were still sent by email to the student's TA and that TA assigned grades. Because the amount of writing was modest, there were no difficulties encountered because of subjective judgment issues between different TAs.

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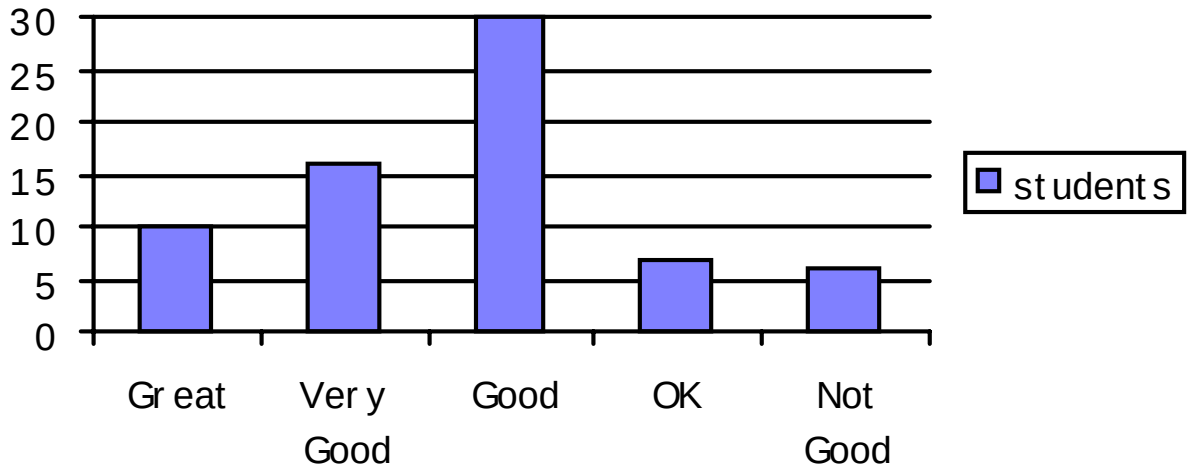

FIGURE 1. STUDENT RESPONSE TO THE INITIAL INCLUSION OF WEB ASSIGNMENTS BASED ON WRITTEN COMMENTS ON THE COURSE EVALUATIONS. 69 OUT OF 110 STUDENTS COMMENTED ON THE ASSIGNMENT.

In this course written comments were again solicited from students at the time of the course evaluation. In this case only 37 students provided written comments about the web assignment. Of those 37, 34 were positive responses; though only six students felt the assignments were very good or excellent, most thought they were good. It is unlikely that the addition of a few sentences of writing brought this relative decrease in students liking the assignment. Nonetheless, neither of these assignments, which were based on learning the web rather than using the web to truly learn chemistry or its applications, was providing a profound impact on student attitudes towards chemistry.

Another intermediate step in our development of meaningful web assignments occurred in a first semester, general chemistry course. In this case a more significant writing component was added. At the outset of this course, we used the introduction of current research topics to help provide motivation for the study of chemistry [10]. As part of this scheme, students were expected to find web sites relating to current research in science with a chemistry connection. Once found, the students wrote one paragraph describing how chemistry plays a role in the research and sent this paragraph and the URL to the instructor. Incentives were devised to entice students to work on this assignment early in hopes of diffusing the grading burden, but these incentives did not work and 65% of the enrollment submitted just prior to deadline. The resulting grading

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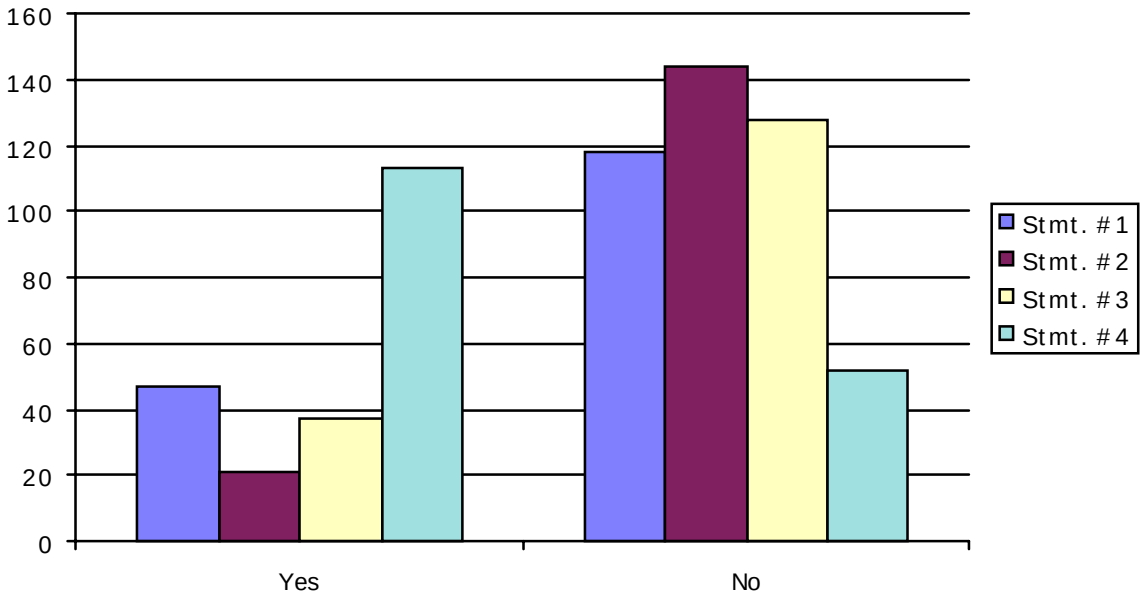

FIGURE 2. STUDENT RESPONSES TO PRELIMINARY QUESTIONS ABOUT THEIR EXPOSURE TO THE WEB. STATEMENT 1 QUERIED PREVIOUS WEB-BASED COURSEWORK IN ALL COURSES WHILE STATEMENT 2 FOCUSED ON WEB-BASED COURSEWORK IN SCIENCE COURSES. STATEMENT 3 ADDRESSED WHETHER STUDENTS WERE ENCOUNTERING THE WEB FOR A FIRST TIME AND STATEMENT 4 ASKED WHETHER THEY HAD EVER SUBMITTED AN ASSIGNMENT BY EMAIL BEFORE.

hassles significantly reduced the effectiveness of the assignment. The time required to find URLs that often included typing errors and then reading of the written work was extensive. A course with 220 students required 7 weeks for grading. In many cases by the time the student work was corrected, URL addresses had changed, further complicating the grading process. Despite these difficulties, we remained interested in determining if students found these web assignments valuable, and we conducted a survey near the end of the semester. The survey was voluntary and anonymous, but did result in extra credit points for those who participated. Partial results of this survey are presented in Figures 2–4. In Figure 2 we summarize some preliminary questions that provide an interesting snapshot of student exposure to web-based assignments. The first two pairs of results refer to the statement: I have had previous (science) classes that used web-based assignments (where the word science is included only in the second statement). Yes (listed first) is indicated by 47 of 165 students for any course but only 21 students out of 165 have experienced web assignments in science classes. This data represents a slight indication that science educators may be behind those in

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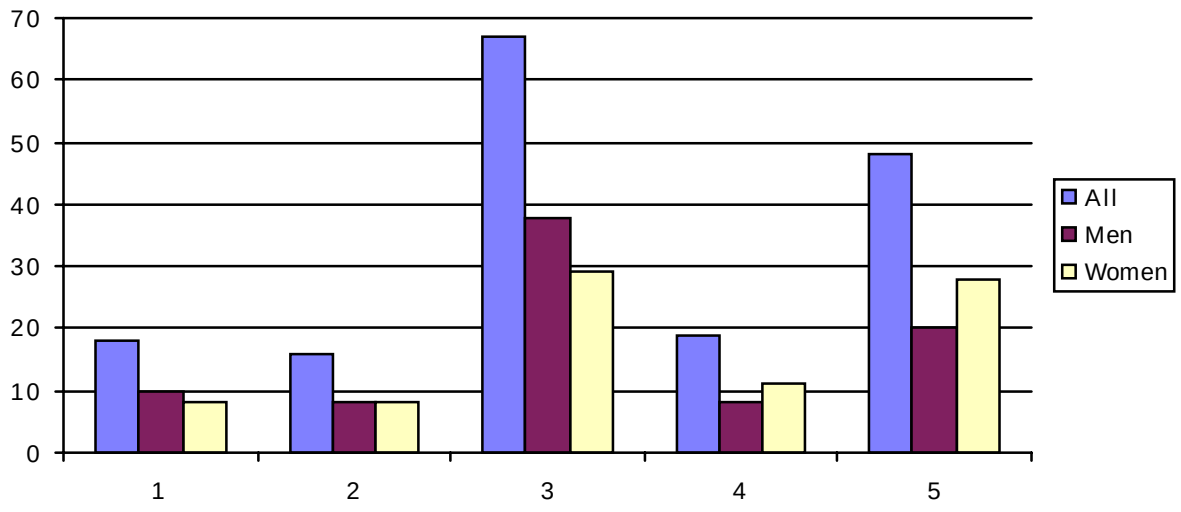

FIGURE 3. ASSESSMENT OF STUDENT FRUSTRATION WITH WAITING FOR A GRADE ON THE WEB ASSIGNMENT. WHILE SOME STUDENTS FOUND THE 7 WEEK WAIT FRUSTRATING, MOST WERE UNDERSTANDING OF THE SIZE OF THE TASK. LITTLE GENDER DIFFERENCE IS EVIDENT.

other disciplines in terms of using the web in their teaching (recall this is a general chemistry course for science majors, so one would expect that these students have a substantial number of science classes.) Response to statement 3, "This assignment was the first time I ever used the web" showed relatively few students with no experience (37). Statement 4, "The web assignment was the first time I ever had to submit by email," showed a higher percentage of first time experiences. Each of these preliminary questions would likely vary for other institutions, but UW-Milwaukee appears to us to be rather normal in its student exposure to technology, so these data may represent a useful snapshot of student usage.

The remaining statements in the student survey required numerical response, where 1 represents strongly agree, 3 represents neutral, and 5 represents strongly disagree. Two statements not summarized here dealt with reliability of the technology; students generally found the technology acceptably reliable. Figure 3 shows student response to the statement "Waiting weeks to find out my score...was 1, very frustrating; 3, slightly frustrating; or 5, not at all frustrating." Total response is indicated first, followed by male then female responses. Relatively few students were highly frustrated by the wait associated with correcting time in a large lecture setting. Figure 4 shows responses to the statement "The material I looked up on the web helped me realize that chemistry

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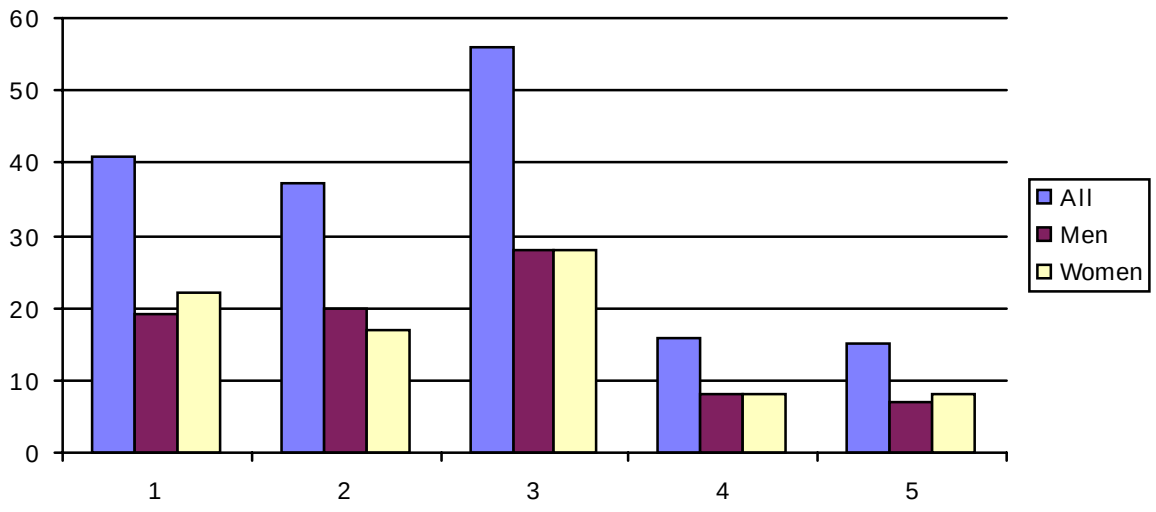

FIGURE 4. ASSESSMENT OF WHETHER THE WEB ASSIGNMENT ENHANCED STUDENT INTEREST IN CHEMISTRY. WHILE THERE IS MODEST AGREEMENT (INDICATING SOME INCREASE IN INTEREST) THE WEIGHTED AVERAGE RESPONSE IS 2.6, BARELY ABOVE NEUTRAL FOR THE STATEMENT. AGAIN, LITTLE GENDER DIFFERENCE IS EVIDENT.

can be an interesting topic to study." While there is some positive feedback for this statement, it is not overwhelming; the weighted average of the responses is 2.6. Based on the inordinate amount of time spent grading the assignment and the modest payback in improved student attitude, the value of this use of the web is suspect. There are no significant gender differences observed for any of the issues we surveyed.

Most Recent Assignment

Our most recent and most successful web assignment was carried out in the non-majors course with 180 students enrolled. The inordinate amount of time spent looking up URLs noted from the previous assignment caused us to approach this issue using a division of labor strategy. Thus, students were required to have significant writing in their web assignments as well as providing URLs, but the addresses were looked up by TAs and the writing was graded by the instructor.

For this assignment, four controversial topics covered in class were chosen for web research projects. These were: (1) increases in air quality standards set by the EPA, (2) the Montreal Protocol and the elimination of chlorofluorocarbons, (3) global warming and the Senate ratification of the Kyoto Accords, and (4) the storage of nuclear waste at

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Yucca Mountain, NV. Students could choose to do either (1) or (2) and either (3) or (4). The assignment required that students find 3 sites on each side of the issue (for example both for and against storing nuclear waste at Yucca Mountain). They were then required to write a paragraph summarizing the arguments of each side and another paragraph indicating their own opinion on the controversy, in light of their research. Examples of good students papers can be found at http://www.uwm.edu/~tholme/c106/webassign.htm.

We have surveyed student attitudes about these projects on two occasions. The first survey found that most students found them valuable but needed help with their web searching. Few students were sophisticated in the use of keyword searching and their naive approaches tended to find only one side of the issue. For example, in the assignment on the Montreal Protocol, keyword searching predicated on the words “Montreal Protocol” reveal few web pages in opposition, even when combined with the word “opposition.” By contrast, substantial numbers of opposing web pages can be found by searching for “expensive freon,” which those who oppose the protocol find most onerous.

We also investigated student attitudes by survey at the end of the semester. In this case an 8 question survey, with statements allowing students to 1, strongly agree; 3, neutral; and 5, strongly disagree is summarized in Table 1. The statement receiving the most positive response (It was much easier to find sites about one side of the issue than the other.) shows that students have some difficulty navigating the internet to find both sides of a controversial issue. This result suggests that assignments that require somewhat more demanding web use are appropriate for learning about the web as both a means and an end. The ease with which the more popular side of an issue can be found on the web further suggests that science educators must consider forcing their students to research both sides of science-based issues so that they are not so easily deceived by misleading information. The statement receiving the second most positive response (The technical aspects—getting an email account, submitting by email, receiving the grade be email—were handled OK.) indicates that students find the technology reliable. UW-Milwaukee is a predominantly commuter campus, so access issues could be a concern, but on the whole access appears adequate at this time. The most negative response (The writing component of the assignment was harder than searching the web.) essentially supports these previous two statements that suggest that learning to do research using the web is a critical component of this assignment.

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TABLE 1. Student Response to Web Assignments Requiring Research of Both Sides of a Controversial Issue.

Statement	1 Strongly Agree	2	3 Neutral	4	5 Stronly Disagree	Ave*
I found the web assignments to be relatively easy	12	40	29	13	4	2.56
The technical aspects —getting an email account, submitting by email, receiving the grade be email—were handled OK.	46	28	18	3	1	1.80
It was much easier to find sites about one side of the issue than the other.	58	26	8	6	0	1.61
Help with keyword searching was important for me to succeed.	21	41	25	11	0	2.27
The second assignment was much easier to do than the first.	17	37	34	7	3	2.41
The writing component of the assignment was harder than searching he web.	6	14	24	60	14	3.43
Doing the web assignment helped me learn much more about that topic in the course.	30	41	22	4	1	2.03
The web assignment would be just as valuable if there was no written requirement and only web addresses were submitted.	16	12	26	27	17	2.77

*Calculated by multiplying responses by the numerical value and dividing by total responses.

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Students disagreed with the notion that the writing component was more difficult than the research component.

Several statements had mixed responses, including those about how easy the assignment was and about obtaining help with keyword searching. One additional statement, however, merits extra discussion. The third most positive response was given for the statement, “Doing the web assignment helped me learn much more about that topic in the course.” This question assesses most directly student attitudes about how the web affects their learning in the course. The preponderance of students express positive attitudes here. This result is particularly encouraging, especially in light of the intention to have the web assignments connect more completely with the chemistry in the course. Note that this statement includes the qualifier “much,” so students who agree with it indicate they feel much more learned about a topic. For such a strong statement, strong support is particularly noteworthy. Several students made comments about the assignment given a prompt to do so at the end of the survey. All but two comments were positive and this one, is perhaps the most eloquent version of a regularly mentioned sentiment; “It ... gave me a good idea of how having more information with a certain bias can affect someone who does not know a lot about a particular issue”. The other most common comment referred to the importance of being forced to use the internet (in all but one case from a positive light).

Quantitative assessment of how this web assignment affects student learning is rather difficult, because there is no control group defined in our implementation. Looking within our experimental group, however, there is at least one sign of its possible impact. We have calculated the correlation between the performance on the web assignments and the examination in the course that tested the web project material. For the first web project (whose median score was a 92% of the available points) the correlation coefficient over 180 students was 0.393, showing only weak correlation between the web assignment score and the test score. Part of the weak correlation was due to students who did not do the assignment and scored 0. By contrast, the second web project (whose median score was 90% of the available points) correlated with the examination score for that material with a coefficient of 0.780 over the same group. There were fewer students who did not do the web assignments in this instance, but this difference does not wholly account for the difference in correlation. The median score on this examination improved to 74% of the available points, up from 67% on the first examination. Thus, examination scores improve in a general sense and correlate better

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with performance on the web assignment when students have completed two such assignments. Improvement on examination scores can by no means be attributed to the web project alone, but there is at least some indication of positive learning outcomes as well as attitudinal improvements among the students.

Our general impression is that this final iteration of web assignments is a very potent way to integrate web-based research into a chemistry course. We intend to continue with this type of assignment in all introductory courses we teach, not only the nonmajors course. We have, however, shifted the burden of accurate web site URLs to the students, as the TAs no longer will search for sites that are not found when they copy and paste the URL from the student submission into their browser.

Summary

We have presented a series of web-based assignments that we have used in our introductory chemistry courses. Our intent was to show, through surveys of student's attitudes, how various assignments influence them. Our incremental improvements may be informative to those who are just beginning to consider how to incorporate the web. In our experience, an assignment that requires the student to find and comment on opposing opinions about a science-based controversy is the best way to introduce the web from several perspectives. (1) It does provide an introduction to students with no previous web experience. (2) This introduction is provided in a rather sophisticated way. Learning to use the web is not an end in such an assignment, but rather an important means. (3) This assignment emphasizes the importance of critical analysis of the content of web pages that are available. Students are then compelled to appraise information based on other experience, hopefully those from the standard content of the course. (4) By dividing the grading responsibilities between the instructor and teaching assistants, this type of assignment can be graded with reasonable efficiency in courses with up to 200 students. There are certainly a number of other ways to incorporate web-based research in chemistry courses. We believe, however, that our current assignment is a good one that should easily port to other institutions and course levels.

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