An evaluation of first year chemistry students: class performance versus use of Internet-based supplementary materials

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Introduction

Over the last ten years the Internet has acquired an aura as a vital resource for learning. It acts as a distributed learning environment available all day every day, a powerful tool for students with too many demands on their time. A web search of virtually any academic topic will turn up a plethora of sites from universities all over the world containing a range of information, from simple lecture notes, sample examinations, interactive problems or examinations, animations, interactive lessons or practicals, etc. The amount of time and effort devoted to production of these materials is incalculable. There has been virtually no research, however, on whether such resources improve student learning or performance in classes. A basic search of *Current Contents* came up with few literature citations; many of these papers report student or faculty opinion of the value of the resources (Agius and Bagnall, 1998; Chang, 2001; Morss, 1999; White and Hammer, 2000). Of the papers that examine student learning/performance compared to use of Internet resources, many fall in the medical community (Agius and Bagnall, 1998; Bell et al., 2000; Erstad and Tong, 1999; Harrold and Dessele, 2000; Hedaya, 1998); the remainder cover classroom learning environments (Buchanan, 2000; Epstein et al., 2001; Frederiksen and Donin, 1999; Poirier and O'Neil, 2000; Sosabowski, Herson and Lloyd, 1998; Thelwall, 2001).

Over the last seven years the author has developed a suite of web-based supplemental materials for first year chemistry students. The intention of the web site materials is to provide a myriad of resources so students with different learning styles will have the best opportunity to perform well in class, as well as provide resources available to students with varied work, class, and family schedules. These materials cover class topics for introductory, general, engineering, nursing, and chemistry major classes, and include well over 250 files including:

- administrative materials (announcements, syllabus, lecture/laboratory schedule);
- narrative format edited lecture notes (Lecture Packets);
- old examinations, as practice test and with detailed explanations of answers;
- interactive practice problems, with hints for wrong answers;
- course specific discussion areas;
- take home quizzes as *Acrobat* files, and answer keys;
- detailed explanations to current examinations;
- grade access; and
- course discussion area.

The edited lecture notes are intended to serve two purposes: save class time by removing the need for students to take many notes and copy problems; and improve student learning by providing an environment where students listen, analyze, and **integrate** ideas instead of taking dictation.

Was it worth the time spent creating these files? How did students use these materials? Did it make any difference in their level of learning or performance in the subject? If nothing else, did they find the materials useful? We are all confident that our web resources are useful to our students, but if we know more about what materials are used, and how, we can focus energies on those materials that make the most difference to students – especially the poorest performing students.

Procedure

Data was collected at Arizona State University (ASU) from 1997. The General Chemistry class is the two semester science and pre-med sequence (called 1A and 1B below); chemistry majors are not in this class (they have their own class). Introductory and Engineering Chemistry are each one semester classes: Introductory has agriculture, nursing, business, and liberal arts students.

The analysis of student use of class web-based materials has evolved over the years as better data mining techniques were discovered. The first attempt at collecting this information involved using page counters to determine what types of materials were most used by students.

The classes are typically 120-175 students. The following data was collected over two years:

Page material	General Chemistry 1A	General Chemistry 1B	Introductory Chemistry	Chemistry for Engineers
Edited lecture notes	>100%	>100%	>100%	>100%
Interactive problems	(15%)	28%	29%	N/A
Old examinations	>100%	74%	N/A	N/A
Explained current examinations	84%	78%	(47%)	>100%

Table 1. Average student hits as percent of class enrolment (from page counters)

Note that less than one third of the class (based upon page counters) used interactive problems; one quarter of the class did not look at old examinations. Even explanations of their own examinations were only accessed by about three quarters of the class – except for the Engineering students.

The page counters give some indication about how students use the course materials – but who are the students that access the old examinations? Who are the students that don't access explanations of their own examinations? The students performing well in class? Those performing poorly?

Students that perform poorly in class – are they taking advantage of these web-based resources? Are the high performing students using these resources? Perhaps students do poorly in class because they don't use these supplementary materials, and high performing students do. The student usage data as determined by page counters raises more questions than it answers. The problem with web-page counters is that we don't know what each student is doing, just the class as a whole.

Results

By March 2000 the class suite consisted of nearly 200 web pages, all cross-referenced and interlinked. Some research was done into generating a database of hit counters linked to student logon ID, but there was little time to learn how to do the programming. Fortunately, in May ASU started using *Blackboard* as a resource for faculty to create web sites for their classes. *Blackboard* (http://www.blackboard.com/) serves as an umbrella program within which the faculty create web pages using a simple editor, create headers and navigation, post files, and use an in-built discussion area (among many other utilities). The discussion area was a desired application, but the ability to track student usage of the web site was the most attractive aspect of *Blackboard*. As each student needed to login to the *Blackboard* program, the data could now be collected on which students accessed which pages.

The summary data for nine classes over three semesters and two summer terms are found below. The data have been analyzed to evaluate:

- which portion of the students use which materials;
- whether students change how they use the web resources; and
- whether there is a correlation between student use and grade.

The July session 2000 of Chemistry 1B was the first class in which usage of the web site was tracked for each student:

Class ranking	Old examinations and explanations	Current examinations explanations	Practice problems
Top 25%	4.1	1.9	4.8
Second 25%	9.1	1.7	6.7
Third 25%	10.2	2.7	8.2
Bottom 25%	7.2	1.6	4.9

Table 2. Student usage (average hits/student) and final grade data from ID tracking
Chemistry 1B Summer 2000

So who are the students accessing these materials?

- Students in the top 25% of the class access the materials least – perhaps they need little supplemental help.
- Students in the third 25% of class access the materials the most – they must find these materials helpful. Are these former D students who are using these resources to boost their grades?

The full data for two different classes over the three 2001 terms (Spring, Summer, Fall) are appended to the paper. The most illustrative data appears within the text.

First semester General Chemistry (1A)

Differences were observed in the use of the web-based materials for the Spring and Fall Chemistry 1A classes. The Spring class is an off sequence group, with students that failed the preceding semester, and other students who for one reason or another have gotten off track; these students are typically the poorest performing class taught all year. The Spring group accessed lecture notes and explained examinations 1.3-1.6 times – indicating they printed out the materials to use them. The old examinations were accessed much more by the middle and poorer students; these resources appear to be more valuable for studying. The Fall group accessed the lecture notes about the same amount no matter their class ranking, but the bottom 20% of students clearly used the old examinations and explained current examinations less than other fractions of the class – one half to one third that of the top 20% of the class.

Class ranking	Lecture notes hits/student	Old examinations and explanations hits/student	Current examinations explanations hits/student
Top 20%	26.0	7.6	6.1
Second 20%	20.6	7.8	5.0
Third 20%	20.1	5.4	5.7
Fourth 20%	15.5	4.9	3.3
Bottom 20%	20.2	3.0	1.9

Table 3. Chemistry 1A Fall 2001
n = 152(158); grade distribution: A=18% B=24% C=30% D=17% F=5%

Students taking the class in the summer term, in which the material from a normal 14 week semester is covered in five weeks, accessed materials much less than students in the Fall and Spring semesters. Essentially all students had 1.0-1.5 page hits per student for all supplement types. This suggests that the summer students simply print the materials out and use them – the time compression of the class precludes time to repeatedly access the resources.

Second semester General Chemistry (1B)

Summer session students for this class are usually pre-med students – highly motivated, hard working students who will take advantage of any opportunity to excel in class. The summer session class showed essentially no variation in student usage of the web resources – all groups by class rank accessed all materials the same amount: 1-1.5 hits per student. These students, like the 1A summer students, simply print the materials out and use them in the time-compressed environment of the summer class. These summer classes are regularly the best students all semester, with over 80% of the class earning A or B.

Class ranking	Lecture notes hits/student	Old examinations and explanations hits/student	Current examinations explanations hits/student	Practice problems hits/student
Top 20%	13.6	4.8	9.2	10.2
Second 20%	14.7	4.2	10.3	10.8
Third 20%	14.4	3.9	10.9	9.2
Fourth 20%	13.0	3.6	8.9	8.2
Bottom 20%	8.2	2.7	3.3	3.5

Table 4. Chemistry 1B Fall 2001
n = 236(243); grade distribution: A=31% B=40% C=16% D=10% F=1%

The Fall semester class had much higher hit rates than the summer, as was observed for the first semester class. Note that for each type of material, the bottom 20% of students had the lowest hit rates – half to a third that of the highest rates for all but the lecture notes.

Additional analysis was done of student hits by performance on examinations versus hit rates. The goal in this effort was to try to identify how students altered their preparation for examinations (as measured by their use of the web resources) as the term progressed. The data below is representative of that observed for all classes:

exam4	top 20%	second 20%	third 20%	fourth 20%	bottom 20%
exam1 chapter notes	12.3	13.0	13.9	14.2	11.3
exam2 chapter notes	12.9	13.9	14.9	15.2	12.0
exam3 chapter notes	12.9	14.1	14.7	14.9	12.0
exam4 chapter notes	12.9	13.8	14.7	14.9	12.0
old exam1&key	5.7	3.7	4.0	3.6	3.1
old exam2&key	5.7	4.1	4.7	4.6	3.6
old exam3&key	4.0	4.3	4.2	3.7	2.7
old exam4&key	3.1	3.9	3.2	3.0	2.5
Current explanations exam1	12.3	12.1	11.1	13.2	13.3
Current explanations exam2	10.1	10.5	9.0	10.7	11.7
Current explanations exam3	9.3	8.7	7.6	9.5	10.7
Current explanations exam4	6.3	5.8	5.4	7.9	7.4
exam1 sample problems	10.1	8.2	9.6	8.0	7.7
exam2 sample problems	10.1	8.3	9.4	8.0	7.7
exam3 sample problems	9.8	8.4	9.5	8.1	7.8
exam4 sample problems			none produced		

Table 5. Chemistry 1B Fall 2001
Student hit rates for Examination 4 materials- lecture notes, old examinations, current explained examinations, and sample problems

The data above show that students do not change how they use these supplementary materials. It is surprising – it doesn't matter if a student does well or poorly on the first examination, they do not change their use of old examinations, explanations of their examinations, or even use the sample problems more.

This might be due to limited usefulness of the web site materials. Student surveys were conducted during the final examination over several semesters and different subjects to determine student opinions and satisfaction with the course materials; students were asked to rate (1-5, 1 being most helpful) how helpful they found:

- lecture notes;
- old examinations;
- explanations to their own examinations;
- sample problems;
- would more sample problems be more helpful? and
- textbook problems.

All classes had the same responses (within a rating of 0.2), the results for the pre-med 1B class Fall 2000 are representative of the survey results:

Lecture notes	Old examinations	Explanations of their examinations	Sample problems	More sample problems?	Text problems
1.3	1.7	1.2	1.5	1.4	2.7

Table 6. Student opinions of helpfulness of supplemental materials (1-5, 1= most helpful)

So it appears that lack of change in student use of the web site is not based upon poor usefulness to the students.

Conclusions

- The lowest performing students seem to rely on old examinations for preparation more that the other groups. They appear to be less concerned about checking their wrong answers on tests (based upon accessing explanations to current tests). These students often don't take as much advantage of the practice problems as the middle half of the class; are they discouraged by their performance? – or do they perform poorly because they don't utilize the supplementary materials as much as their classmates?
- Student use of resources does not change throughout the term – even despite poor performance on early examinations.
- Student use of the web resources is not necessarily predictive of subject performance; however, the general trends observed in the first bullet above indicate there may be a fundamental difference between the weaker students as a group and their use of technology.

Clearly new questions arise as more data is collected. The next step in this project would involve interviews of selected students to get more information about why they accessed resources the way they did. For example: why did one student access the lecture notes for the first half of the class over 70 times per chapter? And why did the same student then drop down to an access rate within the class average?

The real goal of this study is to try and correlate student learning to use of supplemental Internet based resources. In this paper, the student's grade on examinations and final grade in the class have been used as a measure of their learning – their mastery of the subject; this is of course problematic, as a student's performance in class need not have much to do with the learning that occurred. Pre- and post-interviews are necessary to get a measure of actual student learning.

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The data for two different classes over the three 2001 terms (Spring, Summer, Fall) are below:

Class ranking	Lecture notes hits/student	Old examinations hits/student	Current examination explanations hits/student
Top 20%	1.5	1.0	1.4
Second 20%	1.6	11.0	1.5
Third 20%	1.5	3.6	1.3
Fourth 20%	1.5	1.0	2.1
Bottom 20%	1.5	3.4	1.6

Table 7. Chemistry 1A Spring 2001
n = 300(329); grade distribution: A=14% B=29% C=30% D=20% F=8%

Class ranking	Lecture notes hits/student	Old examinations hits/student	Current examination explanations hits/student
Top 20%	1.5	1.0	1.4
Second 20%	1.5	1.0	1.5
Third 20%	1.4	1.1	1.5
Fourth 20%	1.5	1.1	2.0
Bottom 20%	1.5	1.0	1.6

Table 8. Chemistry 1A Summer 2001
n = 56(59); grade distribution: A=28% B=28% C=32% D=12% F=2%

Class ranking	Lecture notes hits/student	Old examinations and explanations hits/student	Current examinations explanations hits/student	Practice problems hits/student
Top 20%	1.5	1.0	1.4	0.6
Second 20%	1.5	1.0	1.5	1.0
Third 20%	1.4	1.1	1.5	0.8
Fourth 20%	1.5	1.1	2.0	0.9
Bottom 20%	1.5	1.0	1.6	0.6

Table 9. Chemistry 1B Summer 2001
n = 66; grade distribution: A=51% B=45% C=5% D=0% F=2%