

Enhanced Learning and Advice Through Online Assignments, A Final Report

Report on the FY09 Academic Technology Award to Kenneth Levasseur and Tibor Beke, UMass Lowell Mathematical Sciences

June 30, 2009

Introduction

During the Fall 2008 semester at UML there were 551 students registered in Calculus I. The students attended large lectures three times each week and also met in one of twenty recitation sections once a week. Students in half of the recitation sections were assigned homework using WeBWork, an online homework system. In a follow-up during the Spring 2009 semester, all students in Calculus I were assigned homework from WeBWork.

Our objective in this study was to examine the feasibility of using WeBWork in this setting, explore student opinions on the system, and see if there is a measurable benefit for students. In this report we summarize our findings.

Summary of work done

During the Fall 2008 semester, 227 Calculus I students who were on rosters after the drop/add period were assigned WeBWork homework. Most of the administration of homework was done by Ken Levasseur, who composed the assignments, managed student lists, and stayed in frequent communication with the students. Tibor Beke communicated with students occasionally, and composed student surveys. A junior engineering student who had considerable WeBWork experience was hired to answer student questions on WeBWork and calculus. The recitation instructor, John Lahoud, also participated through feedback on the problems and with occasional email communication through the WeBWork system.

During the Spring 2009 semester, all 380 Calculus I students from all 11 recitation sections participated in the WebWork experiment. The web administration was done by Tibor Beke, using the templates that Ken Levasseur developed during the fall semester. Much of the communication with the students was handled by the undergraduate TA, with Tibor and Ken assisting as necessary.

In the fall, the following assignments/assessments were given to all WeBWork students:

- Nine problem sets, each with five problems on topics recently covered in the lectures.
- Two quizzes with two problems in each quiz
- A precalculus review set
- A practice final exam

Several students encountered technical problems with the quizzes. For this reason, we only assigned two of them. The problem sets seemed to go much more smoothly, which is why we ended up concentrating on them. The WeBWork part of the recitation grade was based almost solely on those problems sets. Students were given the option of completing an optional practice final and could replace the lowest problem set grade with a higher grade in the practice final. A precalculus review set that was assigned at the start of the semester was optional, to get students accustomed to the system.

In the spring, all Calculus I students were required to do WeBWork homework as part of their recitation grade. These students were assigned

- Eight problem sets, each with five problems on topics recently covered in the lectures.
- A precalculus review set
- A practice final exam

In the fall we surveyed students three times, before, during and after the semester. We did an end-of-the semester survey in the spring.

Statistics.

■ Fall 2008

■ How did the students in WeBWork sections do as compared with other students?

In the following tables,

WW = WeBWork Students

Control = Other students.

Retention with C or better:

	WW	Control
Started	227	270
Took Final	164	180
Percentage Retained	72.2467	66.6667
% with C- or better	0.422907	0.392593

Distribution of final grades by frequency :

Grade	WW	Control	All
A	11	18	29
A-	12	15	27
B+	18	6	24
B	11	19	30
B-	13	6	19
C+	9	12	21
C	14	15	29
C-	8	15	23
D+	9	9	18
D	9	9	18
F	55	61	116
W	58	85	143
Totals	227	270	497

By percentage:

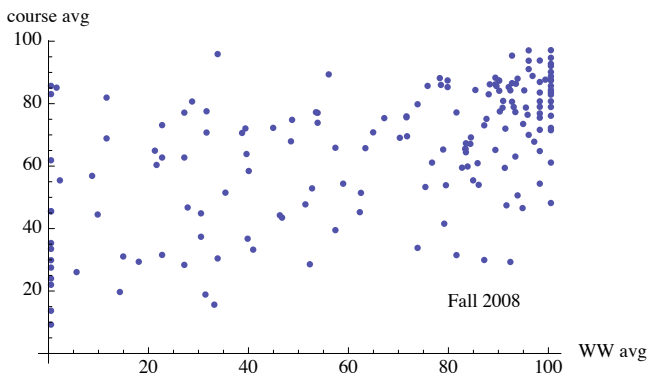
Grade	WW	Control	All
A	4.8	6.7	5.8
A-	5.3	5.6	5.4
B+	7.9	2.2	4.8
B	4.8	7.	6.
B-	5.7	2.2	3.8
C+	4.	4.4	4.2
C	6.2	5.6	5.8
C-	3.5	5.6	4.6
D+	4.	3.3	3.6
D	4.	3.3	3.6
F	24.	23.	23.
W	26.	31.	29.

Exam averages:

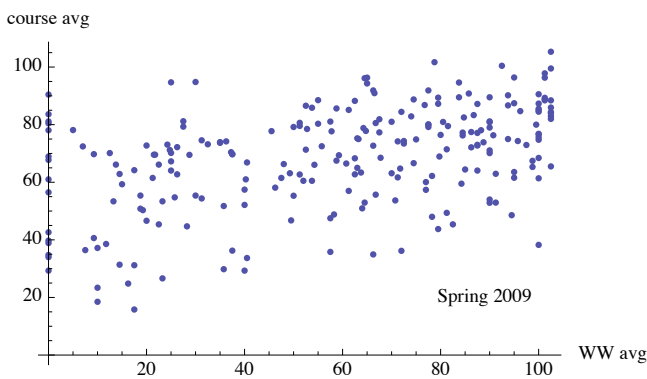
	WW	Control
exam 1	72.0118	71.2378
exam 2	54.3432	54.7351
exam 3	61.3373	58.2486
final exam	63.4268	60.6667

■ **How did students who actually did the WeBWork homework do?**

Not every student in the WebWork sections did the homework. This is a comparison of WeBWork and final course averages for students who took the final exam in the Fall semester.

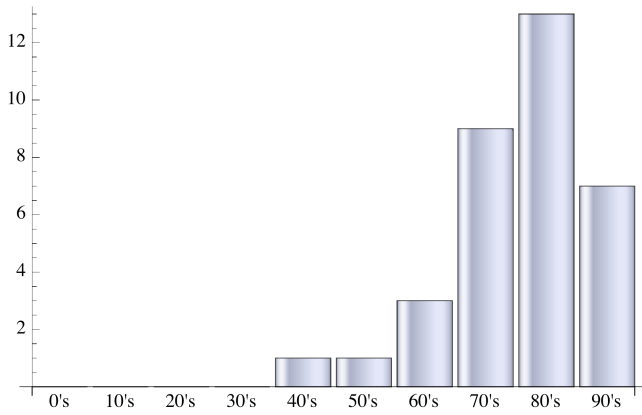


The correlation coefficient for this data is 0.566. In the spring, the graph looks almost identical, with a correlation coefficient of 0.468.

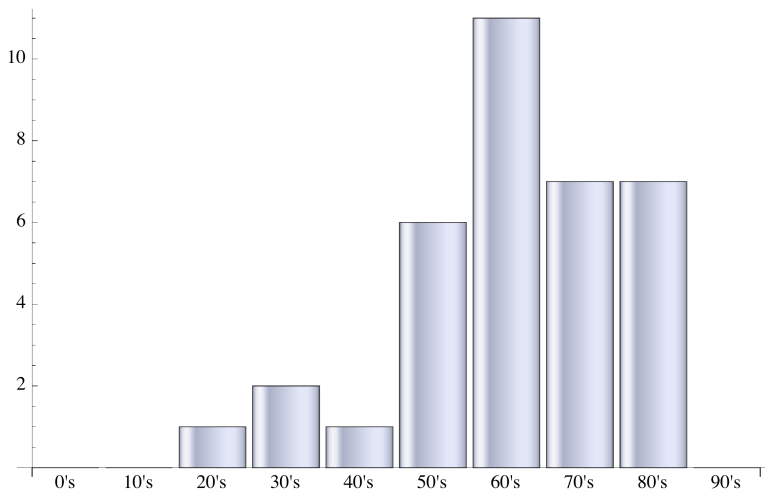


Order Statistics

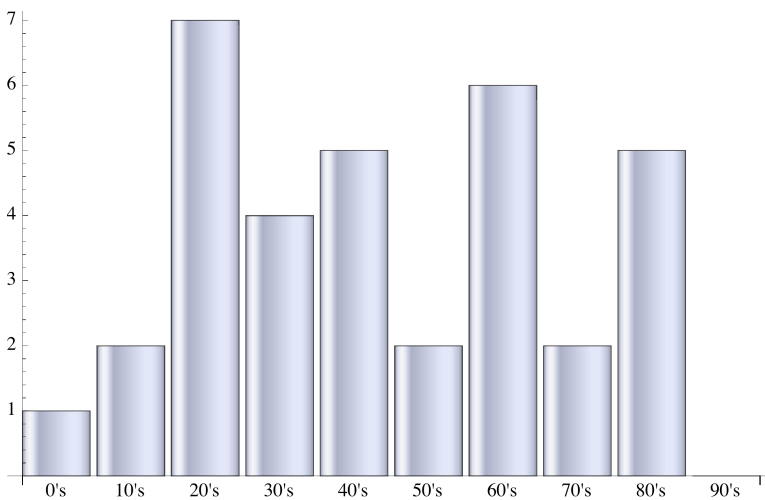
Next, we take the students using WeBWork in the Fall 2008 and sort by their WeBWork average. Looking at the top 20% of the students, we see the following distribution of final course averages.



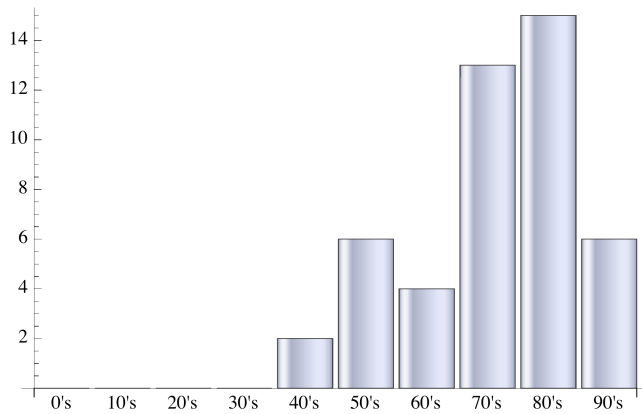
Let's look at the middle 20% of WeBWork grades and see how the final averages compare.



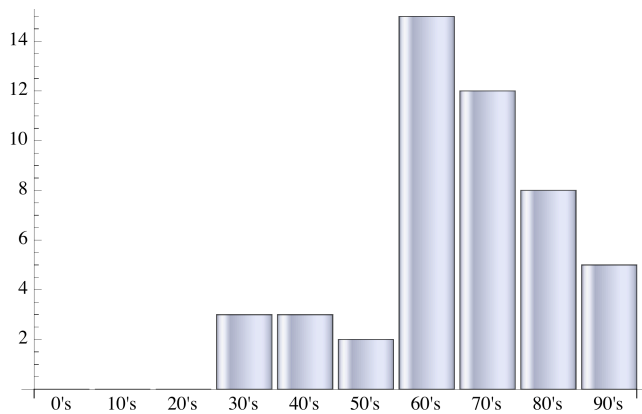
And finally the bottom 20% of WeBWork grades:



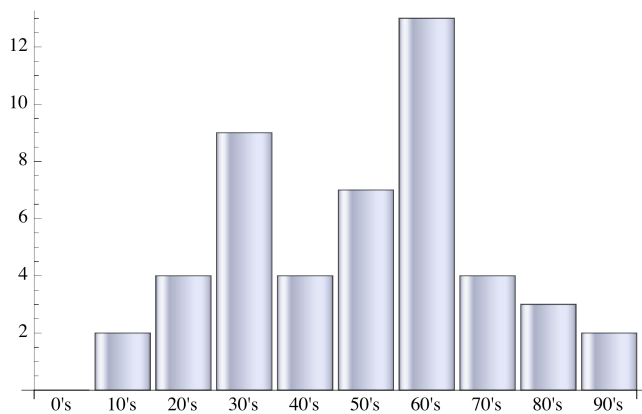
For the Spring 2009 data, we repeated the process and see the following distribution of course grades for students with the top 20% of WeBWork grades.



For is the middle 20% of WeBWork grades in Spring 2009 we see this



And finally the bottom 20% of Spring 2009 WeBWork grades:



Conclusions

1. Although the exam grades and letter grades for WeBWork students were somewhat higher than the control group, the differences do not appear statistically significant. The control group was assigned homework that was graded by the recitation instructors. Therefore, the gain in efficiency using WeBWork was not balanced by any negative effects.

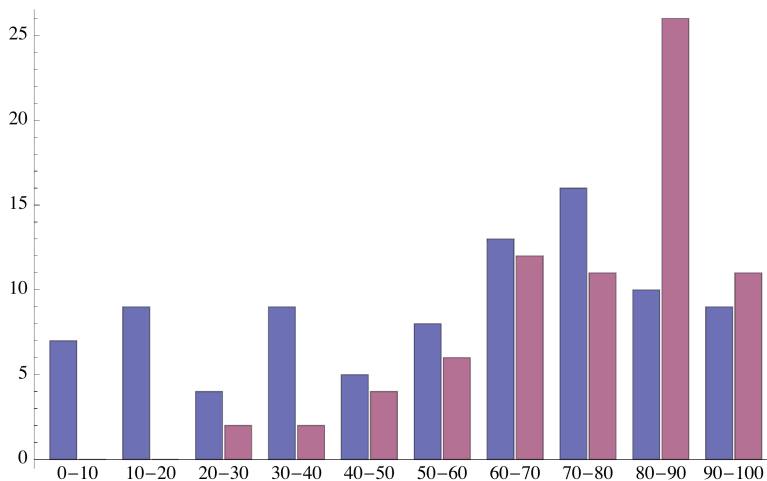
2. The retention rate in WeBWork sections was somewhat higher in the fall. Part of the reason could be that more frequent communications through regular email messages might have kept students more "connected" to the course. We sent out about 2-3 messages per week. After the Fall semester, we surveyed students' opinions of these messages. A significant percentage of students agreed that they were helpful.

8. During the semester, you received regular email messages regarding WeBWork and also the course in general. Do you think that these messages helped you stay connected and informed about the course? Download		
		Response Percent
		Response Count
Yes, they were very helpful		77.9%
They had no effect on me		10.5%
No, they were annoying		10.5%
I didn't get email messages		1.2%
answered question		86

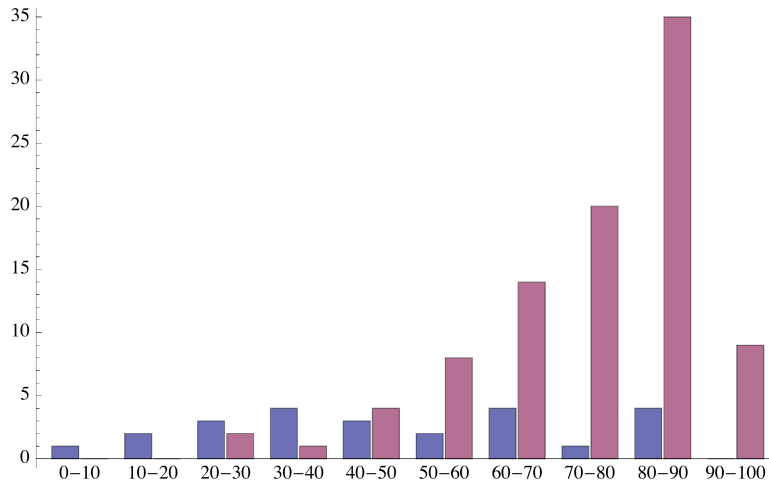
3. The correlation between WeBWork grades and final course grades was weak. The scatter plot shows a wide range of averages for those who completed most of the assignments and also for those who did none of them. In both semesters, we saw what we expected in the sense that the students who had the highest grades on the problem sets also tended to do well in the course. This was true even when the top students didn't have anything to gain (pointwise) by doing the work. They were the ones who took advantage of the practice final even though they didn't really need extra points.

Exam scores and WebWork scores are determined by very different principles. WebWork is computer-graded with no partial credit, but students have an unlimited number of trials and several days to get each problem right. They may also use their textbooks and tutoring services during this time. The primary purpose of WebWork is to reinforce the foundations of the material. This may contribute to the statistical effect that is visible in the scatterplot, that students scoring very high on WebWork (at least 90 on a scale of 0-100) ended up with a wider range of course grades (typically in the range of 70 and more, on a scale of 0-100). The order statistics provides a better alignment of the two scales, and suggests the conclusion that roughly the same cohort of students (about one-fifth of the class) performed best both on WebWork and in the course overall.

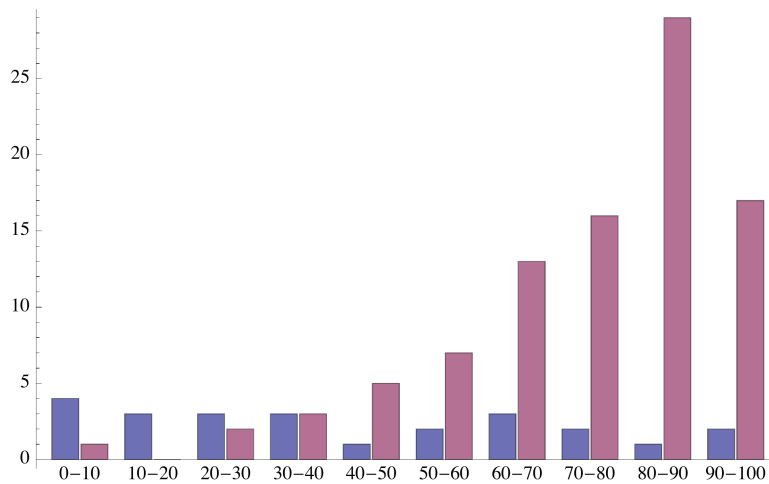
In the fall, 164 of the WeBWork students took the final exam. Of that group, only 74 attempted at least one problem in the WeBWork practice final exam. There grade distribution for the final exam is represented by the red bars. The distribution for the 90 students who didn't attempt the practice final is represented by the blue bars.



This "self-selection" observation is reinforced by the following charts. The red bars represent the distribution of final course grades among the students who did at least 75% of the homework and took the final exam. The smaller population of student who took the final exam and did less than 25% of the homework is represented with the blue bars.



The final exam grades show similar distributions.



4. Administration of the WebWork system itself went quite smoothly. Students reported very few problems doing problem sets. In the Fall mid-semester survey, 87% of students characterized WebWork as "easy" or "neutral" for ease-of-use. In both semesters, one student assistant working around five hours per week was able to answer student email questions. We were surprised to learn from the Fall end-of-semester survey that despite the presence of an "Email Instructor" button on each WebWork page, roughly half of the students were not aware that they could ask for help online.

WebWork → 92131_Calculus_I → 131_Problem_Set_9 → 3

◀ Previous ▲ Prob. List Next ▶

131 Problem Set 9: Problem 3

(1 pt) Use Newton's method to approximate a root of the equation $x^3 + x + 2 = 0$ as follows.

Let $x_1 = -1$ be the initial approximation.

The second approximation x_2 is

and the third approximation x_3 is

Show correct answers

You have attempted this problem 0 times.
This homework set is closed.

In orientation sessions at the start of each semester, we had mentioned that these buttons were active, but this reminds us that mentioning things multiple times is not a bad idea. A bit more effort in the spring increased awareness of this feature.

This issue illustrates a more general concern. We operated the homework system somewhat apart from the main course. Although the instructor for the course, Ron Brent, was very supportive of our efforts, we are convinced that the right person to administer the WeBWork system is the course instructor. More efforts have to be made to coordinate with the recitation instructors and incorporate WebWork (or WebWork-type exercises) during recitations, in an interactive format.

Online homework is but one of several modes of the WebWork software. Two other popular formats are quizzes and gateways. Our experiments with quizzes were only partially successful; many students did not realize that they were being timed and couldn't close their browser window during the quiz. This probably wouldn't have been a major problem if we had persisted, but the problem sets allowed us to ask more questions in a reasonable amount of time, which is why we gravitated toward them.

Gateway exams are a form of proctored quizzes given outside regular class hours when students have to demonstrate competency of some core part of the material before being allowed to continue with the course. The University of Michigan, for example, requires students to pass two gateways in their Calculus II course: one at the beginning of the semester, demonstrating their knowledge of differentiation; and one near the middle of the semester, on integration. Students can attempt each up to three times, and need to achieve a high score (e.g. 90%) to pass. Gateways have proven to be an effective method of incentive and reinforcement in mathematics courses, especially of core skills (e.g. algebra). A major bottleneck in instituting them is the need for proctored computer labs.

Plans for the Future

As part of a revamped structure for Calculus I starting in the Fall of 2009, we will be using an online homework system, but it will be MyMathLab, which is coordinated with the text we will be using that is published by Pearson. Probably the single most significant reason for switching to MyMathLab is the ease-of-use for instructors. Calculus I will be taught exclusively in small lectures and training all of the instructors to be proficient in WeBWork would have been difficult.

WeBWork will still be used in the fall for all Calculus II sections. In the spring, Calculus II will use MyMathLab. We hope to compare the effectiveness of the two systems at the end of the 2009-10 academic year. In addition, we will continue to encourage department faculty to consider using it in upper-level courses, where the level of problems that are available in WeBWork is one of its strengths.