

Implementing and Teaching with WebWork at Mercer University

Jeff Denny

Carolyn Yackel

Department of Mathematics

Mercer University

Macon, GA 31207

(478) 301-5981

denny_jk@mercer.edu

Abstract

WebWork is a free, online homework delivery and grading system developed at the University of Rochester and used at Mercer University for the past three years in teaching calculus. We discuss the features of WebWork that make it preferable to other online homework systems, the technical aspects of using WebWork, and the ways in which faculty and students have been supported in their use of the system.

Introduction

Prior to the 2004-2005 academic year, the mathematics department taught calculus as a three-hour lecture course with a one credit-hour lab that met three hours per week. Materials for the labs were written collaboratively by a committee of mathematics and engineering faculty. The labs were taught by faculty from both mathematics and engineering; therefore, students often did not have the same lab instructor as lecture instructor. In the 2004-2005 academic year, the mathematics department moved to a four-hour class model with no lab. In order to address the desire for a common base to the calculus curriculum, the mathematics department decided to require common online homework sets in all calculus courses. The goal of these homework sets would be to ensure that all calculus students would master a collection of 150-200 computational problems. Thus, we would gain uniformity by using online homework, rather than using common labs, as before, or common exams, as done at larger institutions. Moreover, material on these online homework sets would be cumulative throughout the semester to help students retain material from early in the course. Concepts and comprehensive understanding of the course material would continue to be evaluated via exams, projects, and group work assignments. For the homework delivery the department adopted WebWork, a system that Denny and Yackel had been using with their classes since 2002.

Choosing WebWork

WebWork and Its Features

In 1995, Arnie Pizer and Michael Gage of the University of Rochester began developing WebWork to support lower-level calculus courses at Rochester (Jackson, 1997). Using a web interface, WebWork delivers each student the same collection of problems with coefficients randomized for each student. Problems are arranged in “sets” that can be easily designed and modified by an instructor. As a student submits his/her solutions online, the system instantly responds with “correct” or “incorrect.” The student can then continue to attempt the problem until the due

date and time are reached. This option of repeatedly trying a problem has been shown to encourage students to develop persistence when solving problems (Hirsch and Weibel, 2003).

The web interface for WebWork is compatible with most common browsers and presents students with several key options. As in Figure 1, each student can reset his/her password and e-mail address so that the password is convenient and e-mails from the instructor go directly to the e-mail account used. In addition, students can read messages from both the system administrator and from the instructor.

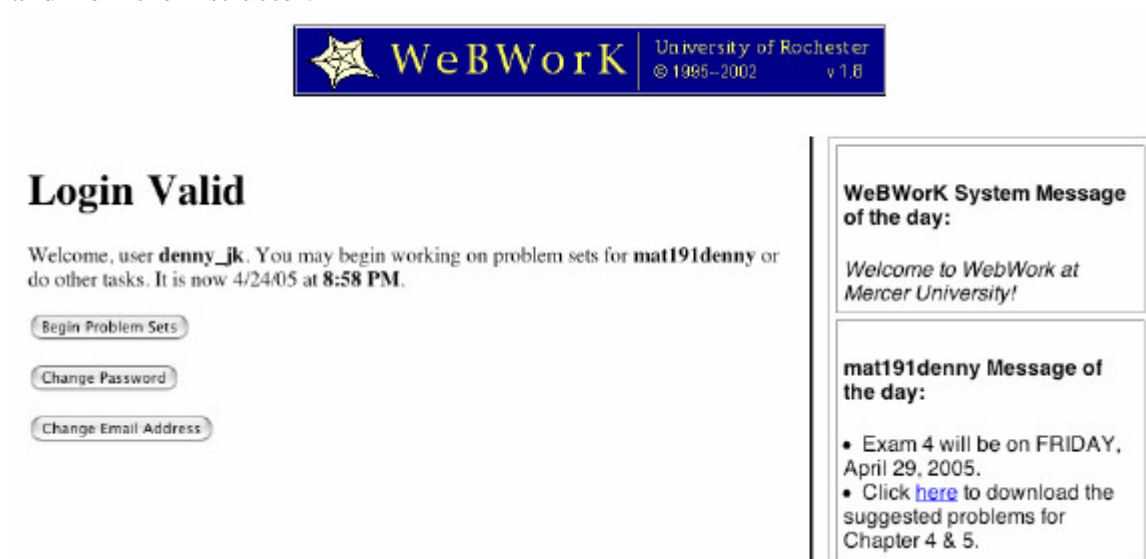


Figure 1: At the WebWork login screen, a student can see the message of the day and update his/her password or e-mail address.

In Figure 2, the screen shows the sets for the course and their due dates. Students may download a PDF of each set, which they can bring to class and the instructor's office hours. Indeed, WebWork students can be identified on campus by these omnipresent printouts of homework sets, usually with notes covering the margins. After the due date, the correct answers are available to the students.



WebWork welcomes Jeff Denny for class mat191denny.



From this page you can view and answer a problem set, download a printed version of the entire problem set in postscript or pdf format, or view a summary of your homework grades. If a set is closed, you can still do the problems and WebWork will tell you whether your answers are correct or incorrect, but your answers will not be recorded.

The date is currently: 4/24/05 at 8:59 PM .

Select a problem set to work on, or to print:

Set 14S05 --- OPEN-- Due date is: 4/27/05 at 11:59 PM
Set 0 --- CLOSED -- answers available.
Set 1S05 --- CLOSED -- answers available.
Set 2S05 --- CLOSED -- answers available.

in: PDF form PostScript form

- Show answers in hard copy IF the answers are available.
 Show solutions in hard copy IF the solutions are available.

Obtain a summary of your WebWork scores:

Figure 2: WebWork lists the homework sets with due dates and times. Students can also download copies of the homework sets in PDF files.

Figure 3 shows a screen at which a student enters an answer. Notice that the student is responsible for using appropriate syntax. The Preview Answer button allows students to view the usual formatting of what has been keyed in. This helps students understand how the computer is interpreting their input.

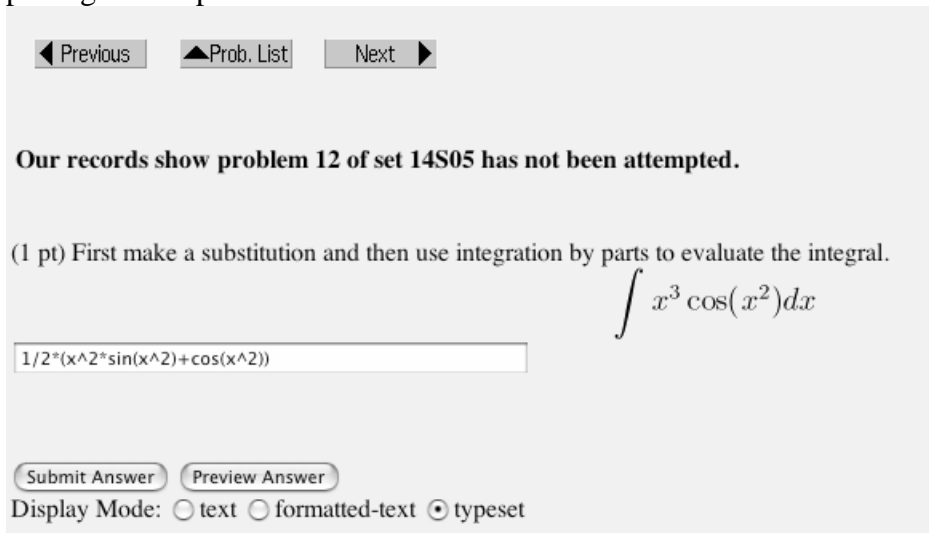


Figure 3: This is a typical screen showing the problem statement and answer box.

Faculty teaching with WebWork have a host of options for customizing their courses. They can change due dates for all or a few students, send e-mails through the system to the class, download grades into Excel, and post daily messages to the class on the login screen.

Advantages of WebWork Over Other Systems

WebWork has several critical features that influenced the Mercer Mathematics Department to choose it over other online homework systems such as WebCT, Blackboard, MapleTA, and MathZone.

1. WebWork allows students to enter algebraic expressions as answers and will recognize equivalent expressions. This feature is vital in mathematics courses, as multiple choice and matching problems significantly alter the approach students take to problem solving. For example, multiple choice questions can be answered by partially solving the problem and then eliminating unlikely answers. In contrast, a problem that requires an algebraic answer must be worked out completely, as the typical answer is nearly impossible to guess.
2. The existing repository of problems was a key factor in our choice of WebWork. Problems are available for pre-calculus, calculus I-III, differential equations, discrete mathematics, probability, statistics, and linear algebra. These questions have been tested at universities across the U.S. and are sorted by topic, making homework sets easy to tailor to accompany any textbook or syllabus.
3. An initial study of WebWork in calculus and pre-calculus courses at Rutgers University showed that students in classes using WebWork made slightly higher grades than those in non-WebWork classes. In addition, those who attempted over 80% of the WebWork problems earned nearly a full letter grade higher in calculus than students who did less than half of the WebWork problems (Weibel and Hirsch, 2002). Moreover, this study demonstrated that students who are taking calculus for the first time benefited the most from WebWork homework. The potential for WebWork to improve our students' performance played a significant role in the department's adoption decision.
4. WebWork is free to educational institutions. Our only departmental costs for running WebWork have been the purchase of a server and the annual academic license fee for Red Hat Linux. Although there is little documentation for the system, the WebWork community maintains a strong and useful support system through a bulletin board at the University of Rochester. The originators, Michael Gage and Arnie Pizer, along with undergraduate and graduate students at Rochester are also excellent sources of help. In addition, the WebWork team at Rochester maintains a concurrent version system (CVS) repository from which system updates can be downloaded and homework problems obtained.
5. WebWork webpages load rapidly. Indeed, WebWork's operations are all executed using a collection of Perl scripts, making the commands run quickly. Moreover, the web interface is not graphics-intensive, ensuring that students and faculty have fast access over any internet connection.

Technical Aspects of WebWork

Purchasing a Server

In 2002, Denny and Yackel first used WebWork in calculus courses by taking advantage of the University of Rochester's offer to host courses on their server for a trial period. When the department adopted WebWork, we negotiated the purchase of a Dell server with dual Xenon processors, a RAID system, a back-up power supply, and one gigabyte of RAM. The university technology support team agreed to maintain and manage the system for us. With the system in place, the unix system administrator installed WebWork and got the web services running.

Technical Support Personnel

The unix system administrator continues to support our system, including WebWork upgrade installations, security management, and operating system upgrades. This person also trouble shoots any problems we encounter. Typically, the problems involve configuration details and changes in settings due to software upgrades. In general, the system administrator commits a few days in the summer to upgrades and a few hours each semester for support.

A faculty member, with the help of a student assistant, does the main work of managing the WebWork system and courses. This faculty member, the WebWork system manager (WWSM), has a wide range of responsibilities. The WWSM enters the homework sets, creates the WebWork courses on the server, maintains supporting webpages, loads the students into each course, edits homework problems, and provides training and support for faculty and students. In addition, he coordinates with the registrar's office to receive files of registered students for each course prior to the start of the semester so that he can load the students into the appropriate courses. As the member of the department most in touch with both the technical and pedagogical aspects of WebWork use, he plays a vital role in coordination of WebWork with the Calculus sequence, as described in section 4.1 below.

Using funds from the Dean of the College of Liberal Arts, a student assistant has been hired each year to aid in the management of the WebWork system. These student employees have been math/computer science double majors who are highly skilled with a variety of interfaces and programming languages and can work in a fairly independent manner. They have been invaluable for writing scripts and programs to simplify routine tasks. The assistant also provides support to faculty and students and edits the homework problems and sets.

Scripts for Course Management

Our courses are organized on the unix system so that each professor has one directory for his/her calculus I courses and one directory for his/her calculus II courses. This means that a professor can easily make changes for all of their sections of a particular course at one time. To simplify the management of these directories, the WWSM and the student assistant have written several scripts and programs, which we would gladly share. (E-mail denny_jk@mercuer.edu for more information).

Before each semester, there is a checklist of tasks that must be accomplished, which is given in Table 1, and most of our scripts address some aspect of this list. Some of the scripts are only useful for setting up courses prior to the semester, while others (update191 and update192) are useful throughout the semester.

Task	Script / Program	Description of Script
1.Create new WebWork Courses on the unix server.	WWSetup	Automates much of the copying and formatting necessary for setting up the directories for a WebWork course.
2.Load faculty into courses.	Use web interface	
3.Set professor permissions.	setperms	Sets permissions for WWSM, student assistant, and instructor to "professor."
4.Copy files for login page.	copyindex	Copies index.html file and graphics files to customize Mercer's WebWork pages.
5.Update index.html files for each.	None	
6.Update the due dates in the sets.	None	
7.Update course and semester in header files	None	
8.Copy problem files, sets, header files into each course.	update191, update192	Copies all files and directories from a prototype course directory into the working directories.
9.Update supporting webpages.	None	
10.Load the students.	MakeClass.java	Converts students' data from Registrar's script into format suitable for WebWork to import.
11.Build the sets.	Use web interface	

Table 1: Checklist for starting a new semester with scripts

When setting up a WebWork course for the first time, there are several files and directories that must be copied, a number of unix permissions that must be set, and a few links created. A student assistant created the WWSetup script which automates this process and calls the course_webwork_setup.pl script that comes packaged with WebWork to initialize new courses.

Once the courses are created, one of the most important steps is obtaining the students' names and registration information from the registrar. The staff at the Registrar's Office at Mercer developed their own script for extracting the data that WebWork needs for each student. The WWSM e-mails the Registrar's Office each semester to ask for the script to be run on a given list of classes. The Registrar's Office then simply e-mails one file for each section back to the WWSM. The program MakeClass.java, written by a student assistant, efficiently converts the

Registrar's information into the format that WebWork requires, and the students can then be loaded into the courses via the web interface.

In the future, we hope to develop scripts for updating the login webpages, the homework set due dates, and course/semester information in header files (steps 5-7 from Table 1). Each semester, these are particularly tedious updates that merely involve changing a few lines in text files and so should lend themselves to automation.

Using WebWork

Educating Faculty

For our department's shift to WebWork to be a success, the faculty needed to be introduced to the system, to have an easy reference on hand, and to have personnel available to answer questions. The WWSM led a brief workshop on WebWork in which he walked the faculty through the student's screens and the instructor's screens in WebWork. He explained the login name and password schemes and demonstrated typical operations that an instructor would need to do on a daily basis. The WWSM also provided handouts that the faculty could give their students on the first day of class to make the students' introduction to WebWork go smoothly.

For quick reference, the WWSM wrote a brief manual for WebWork (version 1.8) that gives step-by-step guidance on how to manage a course (Denny, 2004). The manual includes the department's rationale and goals for using WebWork and addresses how to log onto WebWork, add and drop students, review student progress, send e-mail to a class through the system, change due dates, download grades into Excel, and set the "Message of the Day."

At first, the WWSM and student assistant had to field a fair number of questions about the operation of WebWork. Most commonly, instructors needed help with dropping and adding students into their courses. Other problems focused on students who were logging in with the incorrect password or whose login names in Mercer's registration system differed significantly from their actual names.

The most daunting problem came at the end of Fall 2004 when the WebWork grades for two students in different classes were lost for one of the last homework sets. The instructors were generous in dealing with these situations, and the WWSM worked to find the root of the problem. The source of the problem remains a mystery, although there is suspicion that deleting a student from a course rather than dropping them may cause errors in the grading files.

During Spring 2005, instructors have had relatively few questions about WebWork and have had few complaints. Most appear very comfortable with navigating and managing their WebWork courses and are ready to begin critiquing the homework sets for content and teaching issues.

Due to his detailed work on the WebWork system and the calculus courses, the WWSM has had a particularly focused view of our calculus sequence. Based on his experience, the department's calculus committee has recommended changes in the topics taught in the courses, in the WebWork homework sets, and in the arrangement of exam dates within the syllabus. Having one

faculty member so closely involved in the calculus sequence has provided significant continuity for the courses, as other faculty members rotate through teaching the courses.

Supporting Students

Students have received help with WebWork difficulties through their instructor and through the WWSM. On the first day of class, the students receive two handouts. One describes how to log onto WebWork, and the other describes the syntax for typing mathematics into WebWork. In addition, many faculty insert a paragraph about syntax into their syllabus to help when students get an “incorrect” response on an answer they know is “correct.” At the first attempt to log on, there are usually several students who are not using the correct username or password. Instructors can typically correct this problem with a quick phone call or e-mail. On the whole, modern students adapt very quickly to the system.

The bulk of students’ problems with WebWork occur as the semester proceeds. For example, the campus network in the dorms has had reliability issues this Spring, preventing access to the WebWork courses from the dorms at various times. Typically, instructors have been willing to extend due dates to accommodate such problems. Another common problem is difficulty with typing algebraic expressions into a computer. This skill takes patience and practice on the part of the student, and instructors work throughout the semester to remind students to use parentheses carefully and to use WebWork’s preview option before submitting solutions. The root of this problem is usually in the student’s fundamental lack of understanding of order of mathematical operations. Finally, some of the WebWork homework problems have contained errors, which the WWSM and student assistant have worked to fix. However, since WebWork problems are written in a mix of Perl and LaTeX commands, there have been a few homework problems that we have been unable to fix and have had to eliminate from our standard homework sets.

Conclusion

While the management of WebWork is a time consuming job, the overall effect of using the system appears positive. The ease with which course instructors can make use of this technology accounts for a massive overall time saving in the department, because now there is no need for grading routine problems or labs, though some instructors still assign and grade problems requiring explanations. In addition, the students attempt the WebWork homework at high rates, because they know that every problem will be graded and recorded. Moreover, we allow students to attempt homework problems repeatedly until the due dates with hopes of developing tenacity in problem solving that will translate to persistence in attacking difficult mathematics problems and will even benefit students in courses beyond mathematics. Finally, our requirement that all sections of calculus use WebWork helps ensure that all of our students master a large collection of computational problems and establishes a common set of basic skills for our courses. Given these benefits, we plan to continue using and refining our WebWork homework sets.

Acknowledgments

The authors would like to thank our student assistants, Mr. Lee Bradley and Mr. Britt Daniel, for writing scripts for our system and providing support for students and faculty. We also thank Mr. Scott Lacy, Mercer's unix system administrator, for his diligent work in supporting our needs.

References

- Denny, J. (2004). *Mercer Faculty Guide to WebWork*. Retrieved April 21, 2005 from <http://mathww.mercer.edu/webwork/fac/guide.pdf>.
- Gage, M., Pizer, A., and Roth, V. (2005) *WebWork at the University of Rochester*. Retrieved April 21, 2005 from <http://www.webwork.math.rochester.edu>.
- Gage, M., Pizer, A., and Roth, V. (2002). WebWork: Generating, Delivering, and Checking Math Homework via the Internet, *Proceedings of the Second International Conference on the Teaching of Mathematics*. Retrieved April 21, 2005 from <http://www.math.uoc.gr/~ictm2/Proceedings/pap189.pdf>.
- Hirsch, L. and Weibel, C. (2003) Statistical Based Evidence that Web-Based Homework Helps. *Focus: Newsletter of the Mathematical Association of America*, 23(2): 14.
- Jackson, A. (1997) Whatever Happened to Rochester? Two Years Later, Mathematics is Getting Accolades. *Notices of the American Mathematical Society*, 44(11): 1463-1466.
- Weibel, C. and Hirsch, L. (2002). *WebWork Effectiveness in Rutgers Calculus*. Retrieved April 21, 2005 from <http://math.rutgers.edu/~weibel/ww.html>.