

## AN INTRODUCTION TO WEBWORK

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**Overview** - The reader will find it useful to be connected to the internet and have a browser open while reading this paper. WeBWorK is a free, open source, cross platform program designed for automated homework in college mathematics courses. This paper starts by giving an overview of why one would want to use such a system and the major systems that are readily available. There is some discussion about the circumstances that would lead to choosing each system. We then look at the student experience. Follow up with the instructor experience. Other uses of the system. Issues concerned with hosting. Sources of more information.

### Section 1: Overview of automated homework systems

Automated homework systems for use in mathematics courses are now common enough that they are used in about half of all doctoral granting institutions [1]. The motivation for such systems is pretty straightforward. In discussions with colleagues from a broad range of institutions, the author has found unanimous agreement with the following statements:

- Students are more likely to do homework if it is graded.
- A typical student should do far more homework than the typical instructor has time to grade.
- As a pedagogical ideal, students should get feedback on their work faster than is feasible if it is graded by hand.
- Most homework questions should be free response at a level that is similar to the level of good test or exam questions.

The ideal homework system, which would give feedback of proofs, is not yet available. However there are systems that will adequately handle the bulk of standard problems for a wide range of college mathematics courses. Some minimal thresholds for an adequate system are that the questions should be free response to the level of what might be typed into a calculator, they system should grade mathematically equivalent answers the same way, different students should get slightly different questions, and the student should be able to get immediate feedback on the correctness of an answer. From

survey results [1, 2, 3, 4] and observing what is available from vendors at national math meetings, the top 5 systems are MyMathLab, WebAssign, WeBWorK, Hawkes Learning, and Aleks. Each of these systems has strong advocates. The best choice among them will depend on a number of factors that will change in different teaching situations. The author's department uses three of the systems and is planning to use a fourth, because even at a single institution, different courses have different pedagogical designs.

Among these systems, Hawkes Learning System, and Aleks are more appropriately described as programmed learning environments. The courses they cover generally are below calculus. MyMathLab is a commercial system tied to Pearson texts. It also includes an online text and other online resources. WebAssign and WeBWork are more properly automated homework systems. Neither is tied to a particular text. WebAssign is a commercial product where a student license allows access to homework from a particular text. WeBWorK is open source. WeBWorK can be served either by an institution on its own servers, or through the MAA for a fee.

With the features described above, it is easy to construct a situation where each system is superior. The programmed learning environments are clearly superior in a situation where a student is expected to work in a very independent manner through material that is below calculus. The author uses one of the systems for remediation of mature students who are returning to mathematics after a significant break in their mathematical careers. MyMathLab is closely tied to books sold by Pearson. That is an obvious advantage if a teacher has already chosen a text from that publisher. WeBWorK is open source while WebAssign is proprietary. One might favor either of these depending on how much money or technical support the home institution provides. The other big issue in proprietary versus open source depends on how important it is for the instructor to be able to create questions beyond those in the database of the product.

The author believes that the question of which system to use is much less significant than the question of whether or not to use an automated homework system. In a typical department questions about textbook adoption, student fees, and finding technical support are nontrivial. The author notes that since WeBWorK is open source with a committed community of users, it is generally easy to find an institution willing to host a course or two for the early adopter in a department who wants to explore using an automated homework system.

## Section 2: The student experience

For the reader who wishes to follow along in this section, the student is logged in at <https://ftcourses.webwork.maa.org/webwork2/ft-slu-demo/> [5] using bogusstudent as both the userid and the password. The author finds it useful to have a fake extra student in a WeBWorK class. This allows a classroom presentation that will match what the students see.

A student who signs into a class on WeBWorK is given a list of assignments with due dates. Selecting an assignment in turn gives a list of problems for that assignment. As the picture shows, the student has the option of downloading a hardcopy of the assignment set. This is often useful since many problems ask for an answer but will require more extensive computation. It also allows the student to work on the problems

when they are not connected to the internet. The student can also see the number of times a problem has been attempted and the current score for the problem. The sample section we are looking at concerns basic differentiation.

Name	Attempts	Remaining	Worth	Status
<a href="#">Problem 1</a>	0	unlimited	1	0%
<a href="#">Problem 2</a>	0	unlimited	1	0%
<a href="#">Problem 3</a>	0	unlimited	1	0%
<a href="#">Problem 4</a>	0	unlimited	1	0%
<a href="#">Problem 5</a>	0	unlimited	1	0%
<a href="#">Problem 6</a>	0	unlimited	1	0%
<a href="#">Problem 7</a>	0	unlimited	1	0%
<a href="#">Problem 8</a>	0	unlimited	1	0%
<a href="#">Problem 9</a>	0	unlimited	1	0%
<a href="#">Problem 10</a>	0	unlimited	1	0%

Choosing the first problem in this set gives a standard differentiation problem. It generally is sufficient to tell the students to use graphing calculator syntax, but more detailed instructions are available online [6].

webwork → ft-slu-demo → chapter3section2 → 1

Chapter3Section2: Problem 1    Prev    Up    Next

(1 pt)

Find the derivative of  $f(x) = 6e^x + x^7$ .

$f'(x) =$

Preview Answers    Submit Answers

You have attempted this problem 0 times.  
You have unlimited attempts remaining.

Email instructor

The reader will note that WeBWork keeps track of how many times a student tries the problem and that an instructor can limit the number of attempts. The author generally allows unlimited attempts. Different students in the class get slightly different problems. In the example shown, the 6 and 7 are randomly generated values that are specific for this student. The student also has the option to preview an answer before

submitting. Once the student submits, WeBWorK gives immediate feedback. The feedback generally simply tells the student if the answer is correct.

webwork → ft-slu-demo → chapter3section2 → 1

Chapter3Section2: Problem 1 Prev Up Next

Entered	Answer Preview	Result
$6*(e^x)+7*x$	$6e^x + 7x$	incorrect

The answer above is NOT correct.

(1 pt)

Find the derivative of  $f(x) = 6e^x + x^7$ .

$f'(x) =$

Preview Answers Submit Answers

It is worthwhile to note that WeBWorK will mark an answer correct if it is mathematically equivalent to the answer it is looking for. In the picture below, you see the result obtained by getting the correct answer and then entering an equivalent answer. WeBWorK responds that the answer is correct, and also gives the message that this is equivalent to a previous answer.

webwork → ft-slu-demo → chapter3section2 → 1

Chapter3Section2: Problem 1 Prev Up Next

Entered	Answer Preview	Result	Messages
$6*(e^x)+((7*(x^7))/x)+1-1$	$6e^x + \frac{7x^7}{x} + 1 - 1$	correct	This answer is equivalent to the one you just submitted.

The answer above is correct.

(1 pt)

Find the derivative of  $f(x) = 6e^x + x^7$ .

$f'(x) =$

### Section 3: The instructor experience part I – Responding to student work

If the student sends an email to the instructor from within a WeBWorK problem, the message contains a link that sends the instructor to the student’s problem with the student’s answer. When the instructor follows the link, WeBWorK will note that the instructor is acting as the student. The instructor has a couple of options that are not

available to the student. The instructor can choose to see the correct answer and can also choose to see any worked solution that is part of the WeBWorK problem. These options only become available to the student after the due date of the assignment.

The screenshot shows the WeBWorK interface for a student. At the top, it says "Work MAA MATHEMATICAL ASSOCIATION OF AMERICA". The user is logged in as "mike.may" and has the option to "Log Out" or "Acting as bogusstudent. Stop Acting". The breadcrumb trail is "webwork → ft-slu-demo → chapter3section2 → 1". The current problem is "Chapter3Section2: Problem 1". There are "Prev", "Up", and "Next" buttons. A message says "This set is visible to students." The problem is worth "(1 pt)". The question is "Find the derivative of  $f(x) = 6e^x + x^7$ ." The student has entered the answer  $f'(x) = 6e^x + 7x^6/x + 1 - 1$ . Below the problem, there are options: "Edit this problem", "Show correct answers", "Show Solutions", "Preview Answers", and "Check Answers". A red box highlights these options. A red arrow points from the "Acting as bogusstudent" link to the "Show correct answers" and "Show Solutions" options. Another red arrow points from the "Acting as bogusstudent" link to the "Preview Answers" and "Check Answers" buttons. A red text box says "Instructor acting as student and seeing student's answers." Another red text box says "Instructor has extra options to show correct answers and show solutions. The student only has these options after the due date." Below the options, it says "You have attempted this problem 3 times. Your overall recorded score is 100%. You have unlimited attempts remaining."

Additionally, the instructor has the option of reviewing all of the previous answers that a student has tried for a problem. This allows the instructor to see if the student's errors are likely to be a simple arithmetic or typing mistake, or if they are typical of more serious misunderstandings.

The screenshot shows the "Answer Log" interface. The breadcrumb trail is "webwork → ft-slu-demo → instructor tools → Answer Log". The page title is "Answer Log". There are filters for "Past Answers for" (bogusstudent), "Set:" (Chapter3Sectio), and "Problem:" (1). The main heading is "Past Answers for bogusstudent, set Chapter3Section2, problem 1". Below this, there is a table of answers:

User: bogusstudent Set: Chapter3Section2 Problem: 1	
23 May 2013	
14:53:49	$6e^x + 7x$
14:54:35	$6e^x + 7x^6$
14:55:22	$6e^x + 7x^7/x + 1 - 1$

WeBWorK also allows the instructor to see a more general overview of student progress. Three views are readily available, each of which has its particular strengths. A grade book view gives a summary with the list of students and their scores on each

assignment. This can easily be exported as a CVS file to be read in a spreadsheet. WeBWorK also allows a more detailed view, either focusing on how one student is doing across the collection of assignments or to see how all the students are doing on a particular assignment. These views show the scores and number of attempts on each problem. A notation of C means the problem is correct, a number is a percentage score for the problem and a dot means the problem has not been opened. The second row gives the number of incorrect submissions for the problem.

**Bogus Student**

Set	Score	Out Of	Problems										
			1	2	3	4	5	6	7	8	9	10	11
<a href="#">Chapter1Section1</a>	7.33	10	C	C	50	83	0	C	C	C	0	C	
			4	0	2	1	0	0	0	0	1	0	2
<a href="#">Chapter1Section2</a>	0.00	9	.	.	.	.	.	.	.	.	.	.	.
			0	0	0	0	0	0	0	0	0	0	0

At the author’s institution we have found the scoring tools to be effective in identifying students for early interventions. Students who routinely need more than 5 attempts on problems, or who score poorly on homework in the first month are at a very high risk of failure in the course.

**Section 4: The instructor experience II – Setting up assignments**

Since WeBWorK is open source, it is possible to write one’s own problems. However, the author would encourage users to start by simply selecting problems from the more than 25,000 problems that are already in the problem library.

Add problems to **Target Set:**

Create a New Set in This Course:

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Browse

or Problems from

Subject:

Chapter:

Section:

Display Mode:  Max. Shown:   Hints  Solutions

There are 25895 matching WeBWorK problem files

The problems are arranged for two basic searches. The first method has the problems arranged by subject, chapter, and section. Thus one might look for problems in calculus, differentiation, and chain rule. That would narrow the search down to 394 problems from which to select. The search for Precalculus, Trigonometric Functions, Inverse Trigonometric Functions yields 21 problems.

The other search is the Advanced Search. In this option, one can also specify the book the problems should be taken from. This allows an instructor to create a problem set with problems that follow the style of a particular textbook, either the text used by the class, or a different text whose style the instructor likes.

An assignment can be assigned to the whole class, or to individual students. Creating the assignment involves creating 3 dates, one for when the assignment is available to students, one for when it is due, and one for when the students can see the answers. The instructor can allow for late homework for reduced credit.

More details on assignment creation and management can be found in the instructor documentation section of the WeBWorK wiki. [7]

## Section 5: Broader questions I – Other uses of WeBWorK and new features

For most of this paper we have been discussing WeBWorK as an automated homework system without many bells and whistles. In this section we will discuss some optional features for WeBWorK as a homework system. It is worthwhile to discuss other modes of operation for WeBWorK.

The homework system has a reduced grading period available. This allows WeBWorK to accept homework done on time for full credit, but to count homework done in the grace period for reduced credit. Thus one might count homework that is submitted up to 3 days after the deadline as being worth 80%. WeBWorK allows due dates and assignments to be modified for individual students. This allows an extension to be given selectively for a student who merits one for individual circumstances.

One use of the selective assignments is to provide students with drill assignments from previous courses. It is fairly common to find students who are having difficulty because of gaps or weaknesses in their knowledge from prerequisite courses. Since a WeBWorK course has access to the entire problem library, an instructor can selectively incorporate assignments from previous courses. The author has been using such assignments as follow-up to pre-requisite quizzes in a course.

As was mentioned above, the student progress features of WeBWorK can be used for targeted early intervention. Preliminary statistics at the author's institution shows a strong correlation between the WeBWorK grade and the grade on individual traditional tests. More precisely, we find that over a broad collection of instructors there seems to be a threshold level on WeBWorK that predicts success or failure in a course. (The level varies with the instructor and the policy on how much homework is given, but it seems steady that there is such a level.) We also note that the success or failure can be reasonably be predicted by WeBWorK grades by a point one third of the way through the course. Another red flag seems to be students who take an inordinate number of attempts at a problem.

Several large institutions use WeBWorK in a proctored setting for quizzes, particularly for gateway quizzes. A gateway quiz is typically a timed quiz where the student needs a high score, but where the quiz can be taken multiple times. The gateway module allows for an assignment to be taken under two settings. A student can practice the material independently. In this setting a student can take multiple versions of the assignment for practice. When the student is ready to officially take the quiz it is taken in a proctored setting an instructor or teaching assistant can also enter a code to authorize the scored version. WeBWorK can also be set to restrict the IP addresses from which the quiz can be taken.

One of the current projects for WeBWorK is the development of model courses. This would be a basic set of assignments for a course that has been class tested. It allows an instructor of a standard course to get started very quickly, with the instructor then being able to modify the model course.

As is typical with active open source projects, the feature set of WeBWorK is constantly growing. Two features that should be incorporated into the main version by early 2014 are free response questions and gamification. The free response questions are questions where the expected answer would be a sentence or part of a proof. These questions would have to be graded by the instructor rather than automatically by the program. Gamification is a process of adding game features, like scoring levels or tokens to an application to increase motivation and engagement. Early reaction from sample students is that this would increase the effort by some students.

## Section 6: Broader questions II – Hosting and more information

Since WeBWorK is open source, the question of how courses will be hosted is nontrivial. The author suggests a multi-phase approach that is consistent with an open source community effort. For the first adopter at an institution, the author suggests finding a nearby institution that uses its own server, then asking permission to run an experimental class off their server. (The first WeBWorK class offered at Saint Louis



University, the author's institution, was hosted at Washington University in St Louis, a school down the road.) The MAA keeps a list of schools using WeBWorK at <[http://webwork.maa.org/wiki/WeBWorK\\_Sites](http://webwork.maa.org/wiki/WeBWorK_Sites)> [8]. There are currently more than 100 schools running their own server. This method ties the first user to a more experienced local user.

The second level of scaling occurs when the institution wants to run a number of classes using WeBWorK, but is not ready to run their own server. While WeBWorK is open source, it is also supported by the MAA under a grant from the NSF [9]. The MAA runs a hosting service for WeBWorK, where they will host classes on a fee basis. More information is available on the MAA website [10]. Currently the hosting fee is between \$200 and \$300 per course, with a volume discount for an institution that runs more than 5 courses. The course the author uses for running WeBWorK workshops, that is used throughout this article, is hosted on the MAA site.

A third level of scaling occurs when an institution runs its own server. For financial reason, this is the preferred method at institutions that use WeBWorK for a large number of courses. The community is quite supportive of places that run their own servers, with help being available in the forums.

This article only provides a gentle introduction to WeBWorK. The best source for further information is the wiki [11]. It provides rather complete documentation, with sections for students [6], faculty [7] and administrators [12].

In addition to the wiki, which provides static information, users of WeBWorK should be familiar with the forums [13]. As an open source project, WebWork is based not on a vender, but on a community. A forum is where the members of that community share concerns and insights. It is a good place to get technical help.

## Section 7: Student and instructor reaction

In closing, it is worthwhile to not the student and instructor reaction.

In general the students were positive about WeBWorK in courses where it was used extensively. They liked the immediate feedback to their questions. In particular, they liked the fact that it eliminated the experience of doing a week of homework only to find out that they had done the entire assignment wrong. As a general rule, the weaker students do not know the subject well enough to know when they are going down a blind alley. The author routinely teaches a course that uses WeBWorK, and where the prerequisite course uses a commercial homework system. The author was surprised that students have volunteered that they prefer WeBWorK to the commercial system. When asked for reasons, the students reported that the commercial system had enough hints that they could get through the homework without learning the material.

Instructor reaction has also been positive. Most instructors agree that having students get feedback without too much instructor work is an advantage. Several have noted that the email feature raises the level of discussion in class. Many instructors note that WeBWorK does not handle all of the tasks they would like students to work on in homework, so they supplement the drill WeBWorK assignments with proof and discussion problems done in the traditional fashion.

## References

- [1] AMS Homework Software Survey homepage <  
<http://www.ams.org/profession/leaders/webassess>>, accessed 5/23/2013
- [2] AMS Homework Software Survey full report <  
<http://www.ams.org/profession/leaders/WATSreport.pdf>>, accessed 5/23/2013
- [3] Kehoe, Elaine, Notices of the AMS, p253-257, AMS Homework Software Survey, <  
<http://www.ams.org/notices/201006/rtx100600753p.pdf>>, accessed 5/23/2013
- [4] Bressoud, David, WeBWorK, Launchings, April 2009,  
<[http://www.maa.org/columns/launchings/launchings\\_04\\_09.html](http://www.maa.org/columns/launchings/launchings_04_09.html)>, accessed  
5/23/2013
- [5] Dummy class used for this article, provided so the reader can follow along, <  
<https://ftcourses.webwork.maa.org/webwork2/ft-slu-demo/>>, accessed 5/23/2013
- [6] WeBWorK wiki, homepage, student documentation,  
<[http://webwork.maa.org/wiki/Student\\_Information](http://webwork.maa.org/wiki/Student_Information)>, accessed 5/23/2013
- [7] WeBWorK wiki, homepage, instructor documentation,  
<<http://webwork.maa.org/wiki/Instructors>>, accessed 5/23/2013
- [8] Current list of institutions registered as using WeBWorK, <>, accessed 5/23/2013
- [9] Main support page for WeBWork at MAA<<http://webwork.maa.org/>>, accessed  
5/23/2013
- [10] Information on MAA hosting of WeBWorK courses, <  
<http://webwork.maa.org/faq.html#hosting>>, accessed 5/23/2013
- [11] WeBWorK wiki, homepage, <[http://webwork.maa.org/wiki/Main\\_Page](http://webwork.maa.org/wiki/Main_Page)>, accessed  
5/23/2013
- [12] WeBWorK wiki, homepage, administrator documentation, <  
<http://webwork.maa.org/wiki/Category:Administrators>>, accessed 5/23/2013
- [13] WeBWorK forums, homepage, <  
<http://webwork.maa.org/moodle/mod/forum/index.php?id=3>>, accessed  
5/23/2013