

# Webworks: a useful teaching tool for instructors using i-clickers and peer-instruction

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**Abstract:** As an instructor who commonly devotes as much as a third of class time to i-clicker use and peer-instruction, it is essential for me to streamline my lectures. Covering topics in sufficient depth therefore requires me to rely on students carefully reading the textbook before coming to class. This is easier said than done without some means of holding students accountable. I have found Webworks, a system of online exercises, to be very helpful in this regard. I have used Webworks as a way to get students to read ahead and to anticipate upcoming material. Webworks has many benefits for both students and the instructor. It makes students more independent learners and informs them what sections in the reading to focus on. As well, it gives feedback to the instructor before he/she steps into the classroom on what material students are having difficulty with. It also helps detect which students aren't doing the work necessary to succeed in the course.

## **Introduction:**

Webworks is one of a growing number of web-based homework systems available today<sup>1</sup>. Arnold Pizer and Michael Gage in the Mathematics Department at the University of Rochester designed it specifically for mathematics in the early 2000s. Today it is the largest open source system, used at over 150 colleges and high schools. It has recently been installed at Saint Mary's college of California and is free for instructors and students to use<sup>2</sup>. In addition to multiple-choice responses, this system can grade free response numerical answers, free response answers involving mathematical expressions, and, in fact, any type of answer for which it is possible to write programmed instructions to determine correctness. Each student sees individualized problems, gets immediate feedback on whether or not the problem is correct, and is encouraged to continue reworking the problem until he or she gets the correct answer. The instructor gets detailed statistical

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<sup>1</sup> <http://webwork.math.rochester.edu/>

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information on how students performed individually and collectively on all assignments.

There have been a number of studies done about the effectiveness of Webworks on student learning (Cassady, et al. 2001, Denny and Yackel 2005, Dufresne, et al. 2002, Gage, Pizer and Roth 2003, Hauk and Segalla 2005, Hirsch and Weibel 2003, LaRose and Megginson 2003). What is clear is that Webworks doesn't have a negative effect on student learning and in some cases has a positive one. The greatest gains come when Webworks is supplemented with a lab where students can get help entering their answers into the computer (Hirsch and Weibel 2003).

In this paper we will concentrate on the effects of using Webworks, in conjunction with i-clickers and peer instruction. For an introduction to i-clickers and peer instruction see (Lucas 2009, Mazur 1997). My interest in Webworks grew out of my wish to hold students accountable for reading the textbook outside of class. I needed to have some feedback before entering the class about what students were understanding and not understanding from the textbook so that I could streamline my lecture. For each class I assign typically 8 Webworks questions covering the main topics I want students to take away from the reading. The reading assignment is due the night before the next class so I have time to reflect on student's responses. To streamline my lecture I concentrate on topics that students had trouble answering questions about. Typically, in a 60-minute class, I spend 10 minutes reviewing homework (separate from Webworks reading comprehension questions), another 30 minutes lecturing in response to students Webworks answers, and spend the remaining time with i-clickers and peer instruction testing their understanding of the material.

### **Results and Discussion:**

Webworks multiple choice reading comprehension questions was used in three different classes at SMC during the fall of 2007. I wanted to see the applicability of Webworks in classes with different student populations. There was an upper division Probability and Statistics class, a lower division Introduction to programming class for science majors, and a general education Finite Mathematics class. Webworks questions tested students reading comprehension on material the students hadn't been lectured on. Figure 1 shows a typical question from my Programming class. It can be answered by carefully reading the textbook for the course. The Webworks problems would be due before class and I would routinely adjust my lecture

in response to what students had difficulty with. Students received a Webworks score for questions answered correctly that counted towards their participation grade.

In each of my classes I had students keep track of how long they spent reading when Webworks questions were assigned and when Webworks questions weren't assigned. Figure 2 shows that on average in my three classes 44 percent of students increased their reading time by 10 minutes per night and 83 percent of students read 10 minutes or more per night. Students who read more appeared to benefit more from peer instruction and i-clickers. Although the direct effect on student performance wasn't measured, qualitatively I could tell that students seemed more prepared for class when Webworks questions were assigned. I would use student's responses to Webworks questions as a launching pad to a discussion.

Using Webworks has its challenges. It is important that the students are able to read the textbook. The instructor might need to devote time at the beginning of the semester to train students to read critically. A smart room with an overhead projector is necessary. As well, developing good multiple-choice reading comprehension questions from scratch can be time consuming. Fortunately, Webworks has a library of questions tied to specific textbooks. I would adopt a textbook that had multiple-choice reading questions at the end of every chapter and copy these questions into Webworks. It is important to explain to students why you are doing Webworks. Otherwise the students might complain that it is the teacher's responsibility to "teach" the students and they shouldn't have to learn from the textbook. I emphasize that because of limits in class time, we won't be able to do peer instruction and i-clickers (which is usually very popular) unless students learn to read the textbook and become more independent learners. I tell them that Webworks gives me feedback on what they are taking out of the reading.

There are many benefits to using Webworks. By the end of the semester the majority of my students appreciated the benefits of reading comprehension questions using Webworks. As figure 3 shows, 82 percent preferred having Webworks compared to no Webworks. The reason is that Webworks helps focus students in their reading and keys them into what the instructor thinks is important. They appreciated getting immediate feedback about the correctness of their responses. Many students used Webworks to motivate themselves to read since it was a part of their participation grade. Students

also appreciated that it is free to use. Another large benefit for the instructor of regularly using Webworks is that student's Webworks score correlates well with i-clicker scores and overall performance in the class. In figure 4, you can see that students Webwork's score had a correlation coefficient of  $r=0.73$  with their overall grade compared with  $r=0.79$  for i-clicker scores and  $r=0.80$  for homework. Here the i-clicker and Webworks component of the final grade is temporarily removed from the calculation. Webworks provides an easily obtained predictor of overall student performance in the classroom. Taken together with i-clicker scores, the instructor gets an early indication which students need extra help.

### **Conclusions:**

Using Webworks for reading comprehension has useful benefits for both students and the instructor. Students learn to become more independent learners. It is a popular and effective means of getting students to read more. For an instructor trying to streamline his/her lecture to make room for i-clickers and peer instruction it provides valuable information on what students do not understand when they step into the classroom. The good correlation between Webworks score and overall performance (figure 4) indicates that students with low Webworks scores tend not to be successful in the class and should receive extra support early during the semester.

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**Multiple choice**

In Python, indefinite loops are implemented using a

- A. file loop
- B. loop and a half
- C. while-loop
- D. for-loop

Figure 1. A sample Webworks problem used for reading comprehension in a Programming class.

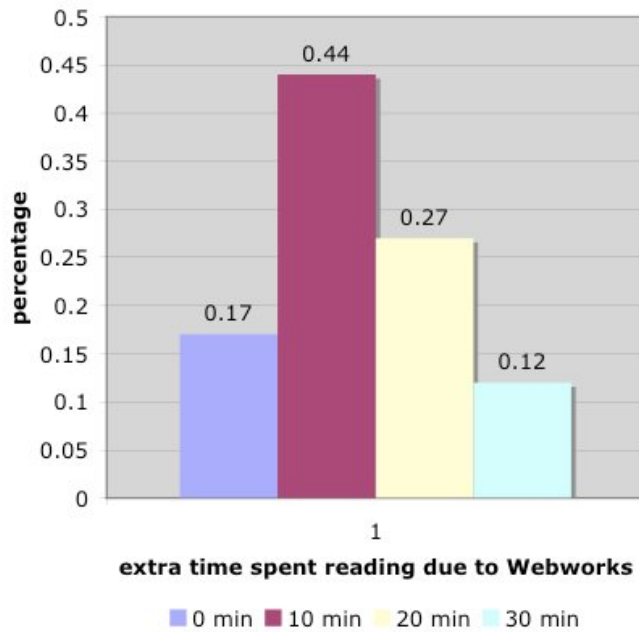


Figure 2. The majority of students (83%) spend more time reading their textbook when they are required to answer Webworks questions before coming to class.

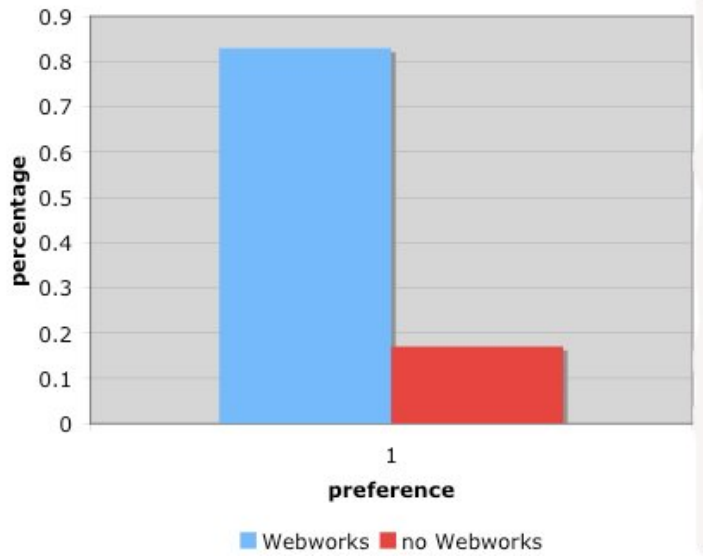


Figure 3. Students prefer having Webworks in the class because it gives them an idea of what the instructor wishes them to focus on in the reading.

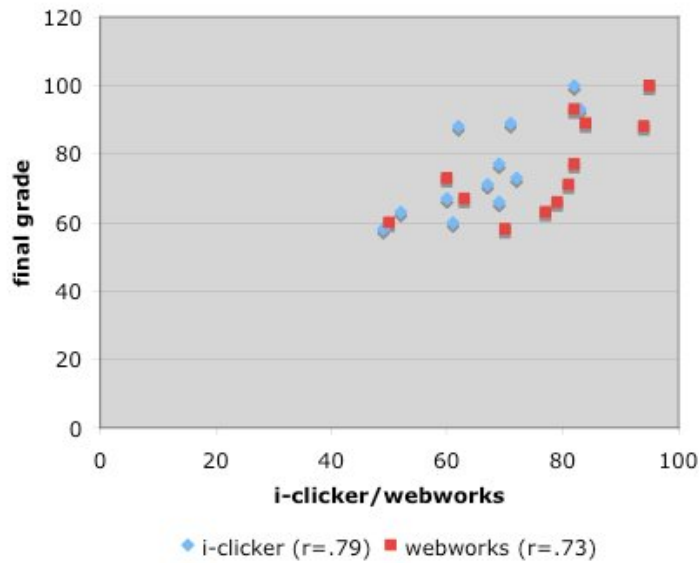


Figure 4. Webworks and i-clicker scores provide the instructor with meaningful data on student performance.