

# REWARDS AND CHALLENGES IN USING WEBWORK IN A MULTIVARIABLE CALCULUS COURSE

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*I will describe the rewards and challenges in using WebWorK in a Multivariable Calculus Course at Brown University during spring semester, 2019. In addition, the results of a student survey about the ease and use of the software will be summarized*

*Keywords: WebWork, Multivariable Calculus*

## BACKGROUND

I was assigned to teach multivariable calculus less than 2 weeks before the beginning of spring, 2019 semester. I understood that the course was to use the website that was developed by the original instructor; this website used both Canvas and Webwork. I had used the Learning Management Systems of Blackboard and Sakai and thought that I would be able to transfer my knowledge base to Canvas. For computer generated problems, I had previously used commercial textbook software, so I was not concerned about my being able to learn how to use WebWorK.

## Description of WebWork

**WebWorK**, developed by the University of Rochester and supported by the MAA and the NSF is open source and includes a National Problem Library (NPL) of over 20,000 problems for the following courses: college algebra, discrete mathematics, probability and statistics, single and multivariable calculus, differential equations, linear algebra and complex analysis. To create a homework assignment or quiz, the user first selects “library browser;” the software then provides the user the choice of the subject (such as multivariable calculus), chapter (such as vector geometry) and section (dot product, length and unit vector). WebWorK can be integrated into various LMS systems such as **Blackboard, Moodle** and **Canvas**.

## Rewards for using WebWorK:

The major advantage for both the instructor and student is that the problems are automatically graded. The instructor saves time grading and the student gets immediate feedback. In addition, WebWorK provides useful statistics such as the percent who answered a question correctly, the median number of tries required to get the correct answer for each problem. WebWorK also provides the number of times that each student needed to solve a problem.

## Challenges for Using WebWorK

The major challenge was that the grades earned on homework or quizzes in WebWorK were not automatically generated into the LMS. Since WebWorK has its own Learning Management System, the instructor must access the grade in WebWorK and then manually insert these values into their LMS.

Another major challenge was that WebWorK does not allow certain inputs; as a result, some problems with incorrect input were not marked correctly. For example, students had trouble when the answer involved special constants such as pi.

Finally, while WebWorK is a free software, the institution needs to find a server to host the software. MAA will host members for one semester only, but then charges \$200/course to host WebWorK.

**Description and Analysis of Student Survey of use and ease of software**

Ninety-two of the 110 registered students completed a survey about their opinion of the WebWorK Homework. There were five multiple choice questions and 2 open ended question. The following 5 multiple choice questions were asked:

1. How many hours do you spend on the WebWorK homework?

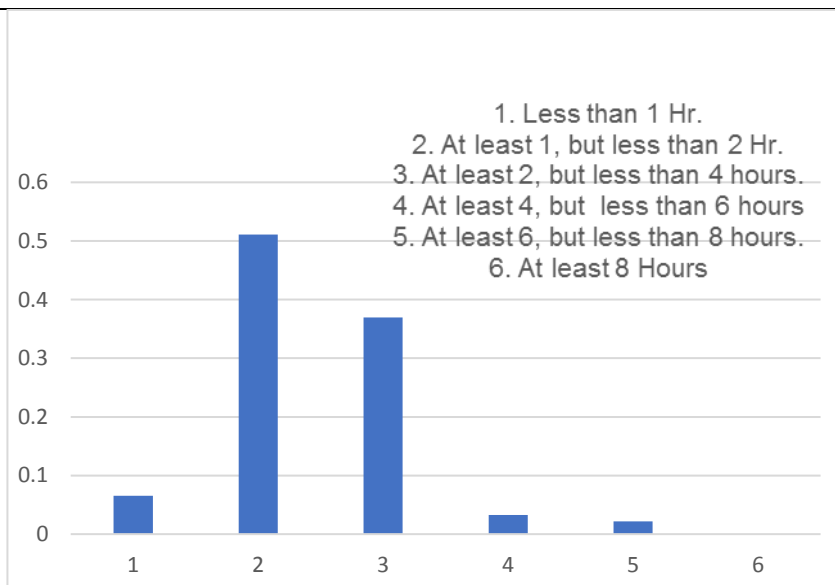


Table 1: Time Spent on WebWorK

Approximately eight WebWorK problems were assigned each week. The majority of the students (51%) spent between 1 to 2 hours on the WebWorK homework, while about 37% spent between 2 and 4 hours per week. All students spend less than 8 hours a week.

**2. Are WebworK assignments too short, somewhat short, about the right length, somewhat long or too long?**

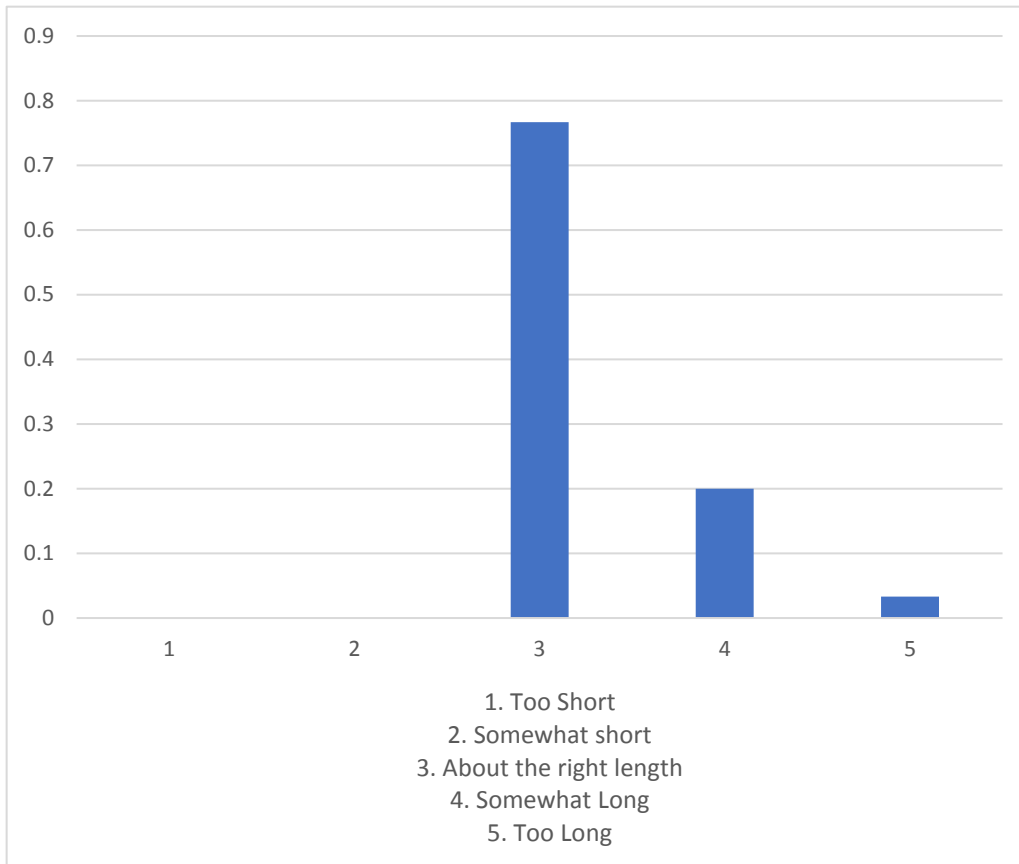


Table 2: WebWorK Assignments are:

The majority of students felt that the WebWorK assignments were about the right length.; No one felt that the assignments were short, and only 20% thought the assignments were somewhat long.

### 3) How was the process of entering the answer?

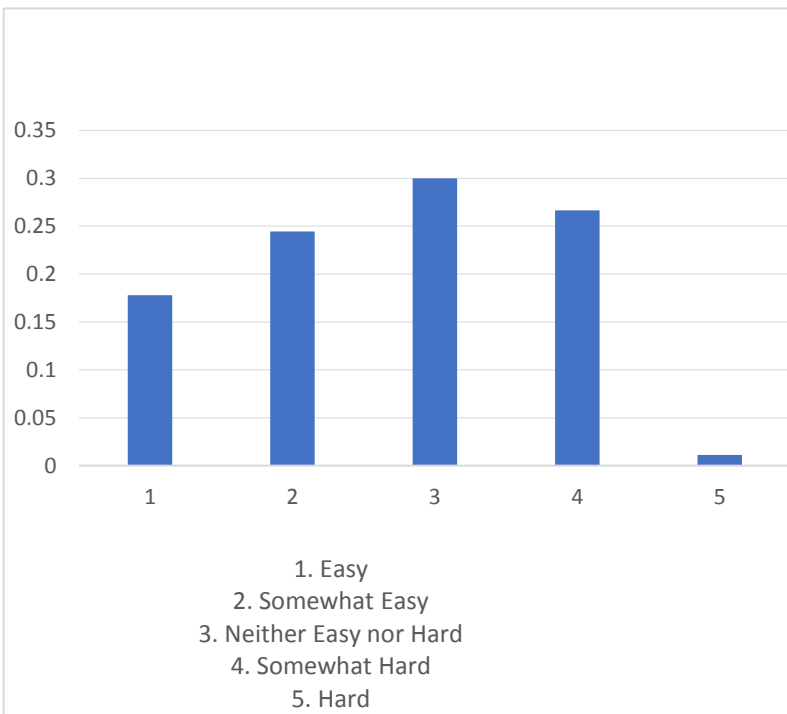
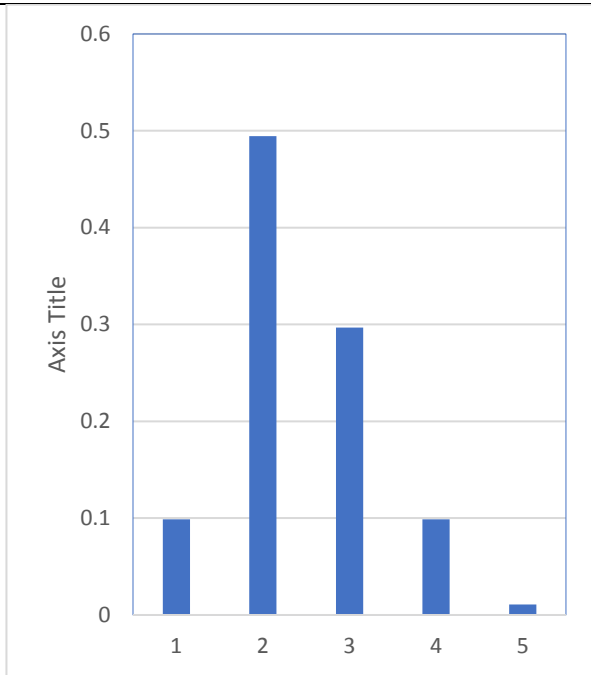


Table 3: Entering answers is

Students were divided in their opinion of the ease of entering the answer. While 30% thought entering the answer was neither easy nor hard, 27% thought it was somewhat hard and 24% thought it somewhat easy

4. How useful was WebWorK in helping you understand the material?

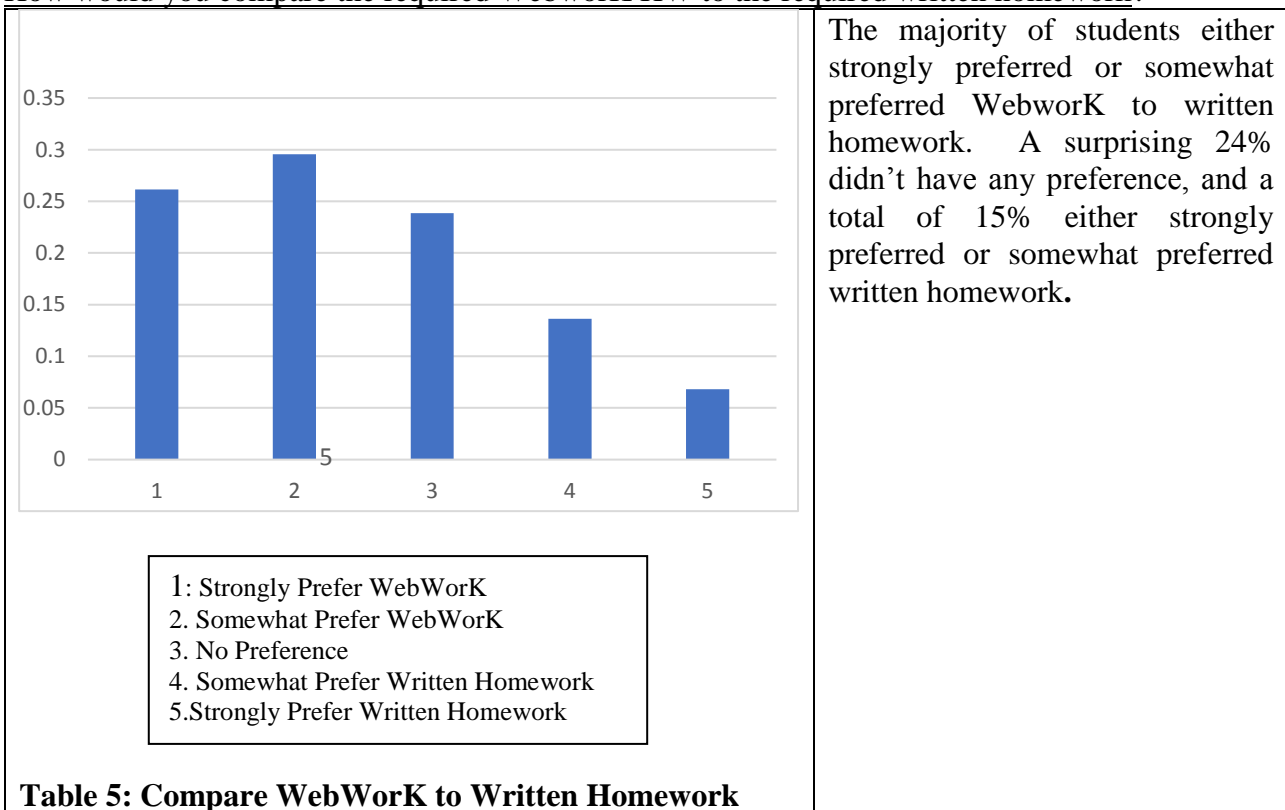


- 1: Extremely Useful
- 2: Very Useful
- 3: Moderately Useful
- 4: Slightly Useful
- 5: Not Useful

Table 4: How Useful was WebWorK in Helping you Understand Material

Most students felt WebWorK was extremely or very useful, 30% felt the tool was only moderately useful. Around 10% thought WebWorK was slightly useful and a mere 1% thought it was not useful at all.

5. How would you compare the required WebworK HW to the required written homework?



When asked what they liked about using WebWorK, most students answered: immediate feedback, ability to enter alternative answers without penalty if the initial answer is incorrect, and that there was no time limit to solve the problems. On the other hand, students response to what they disliked included the following: that there was both written and computer homework, that some math symbols were not recognized for answers and the number of decimals required for an answer was inconsistent and not provided

The survey asked students if they had used computer homework in any other course, and if so, whether they preferred WebWorK or another system. Most students replied that they had not used any other computer homework in other courses. A few mentioned Sapling, a computer homework in chemistry and WebAssign, a commercial homework system. Of those who used other systems, most preferred WebWorK, although a few preferred Sapling because it gave hints.

The University of British Columbia (<http://www.math.ubc.ca>) has been collecting survey data for students who use WebWorK in mathematics. In particular, the results of the survey for their multivariable calculus course (Math 253) found comparable results (<http://www.math.ubc.ca/~cwsei>) to what was found in Brown's Math 180. Dr Vicki Roth and others (Roth et al, 2008) at the University of Rochester, evaluated survey responses of 2387 students and found that students especially liked the immediate response that WebWorK provides; they disliked the fact that WebWorK could not provide them with partial credit and was unable to let them know if their answer is "almost correct."

## **Summary and Relevance to Other Studies**

While learning WebWorK was challenging, the benefits far outweighed the disadvantages. In general, the students liked the online computer homework, and found it easy to use.

Many institutions now use WeBWorK and the literature describes the advantages and techniques for using this open source software successfully. For example, Dr. Grace Kennedy (Kennedy) from the University of California at Santa Barbara recommends that instructors require both WeBWorK and written work in order to encourage meaningful engagement; according to Dr. Kennedy, “ In a differential equations class, the teacher can select four to five topics that are not well tested by WeBWorK and have students submit a written assignment on these topics.”

Many WebWorK users have written testimonials (<http://webwork.maa.org>) for WebWorK. For example, Tom Shemanske (Dartmouth College) lists many advantages of WebWorK including: instructors can use any textbook, more problems are continually added, and the product is extremely flexible to the needs of the individual instructor. In addition, the MAA webpage also cited many instructors (For example Lars Jensen, Truckee Meadows Community College and Mel Hochster and Gavin LaRose, University of Michigan) have found that WebWorK is superior to commercial computer systems that they have used.

In a 2010 AMS online survey of 1,230 U.S. mathematics and statistics departments (with a response of 467) asking for their experiences using homework software found that all software systems received praise (Kehoe, 2010). At this time, most software used was commercial: MyMathLab was used by 230,000 students; WeBWorK by a little over 100,000 students; and WebAssign by a little under 100,000 students. It is now possible to check the locations and schools that are using WebWorK. The map that the MAA ([http://webwork.maa.org/wiki/WeBWorK\\_Sites#.XZzm41VKiU](http://webwork.maa.org/wiki/WeBWorK_Sites#.XZzm41VKiU))

provides indicates that the majority of WebWorK users reside in the United States and Canada. This imbalance is probably because WebWorK was designed by the educators at the University of Rochester and the rest of the world is not yet aware of this amazing free software.

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