

**Learner-Centered Education Program**  
Arizona Board of Regents  
**INSTITUTIONAL SUPPORT FORM**

Proposal Title: WeBWork in the Calculus Curriculum

Institution: Northern Arizona University DEPT/Unit: Mathematics & Statistics

Multi-Campus/University Projects  
(check other campuses or universities  
participating)

List other participating agencies:

ASU Main  UA

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*Briefly describe the program and the development plan.*

This project proposes to improve student mathematical learning in the Calculus sequence by using the WeBWork online homework system. WeBWork will be piloted in the Spring 2004 semester in some sections of Calculus and more extensively implemented during the 2004-2005 academic year.

**Funding Category**

Indicate a primary (P) and, if applicable, secondary (S) funding category:

Professional Development  S

Program or Course Development/Modification  P

LCE Research

Improved Assessment of Learning Outcomes  S

**Authorizations**

**Project Director**

Signature: \_\_\_\_\_

Mailing Address: Department of Mathematics, Box 5717, NAU, Flagstaff, AZ 86011-5717

Name: Janet M. McShane Title: Associate Professor

Phone: 928-523-1252 Fax: 928-523-5847 Email: Janet.McShane@nau.edu

**Department Chair / Unit Director/ College Dean/Provost**

Name: Roy T. St. Laurent Title: Department Chair

**Signature**

**Official Authorized to Enter into Contractual Obligations**

Signature \_\_\_\_\_

Name: \_\_\_\_\_ Title: \_\_\_\_\_

Phone: \_\_\_\_\_ Fax: \_\_\_\_\_ Email: \_\_\_\_\_

c/o Arizona Board of Regents  
2020 N. Central Avenue, Suite 230  
Phoenix, AZ 85004  
Phone: 602-229-2500 • Fax: 602-229-2555  
[www.abor.asu.edu](http://www.abor.asu.edu)

# **WeBWork in the Calculus Curriculum**

## **Part 1: Abstract**

This project proposes to improve student mathematical learning in the Calculus sequence by using the WeBWork online homework system. WeBWork will be piloted in the Spring 2004 semester in some sections of Calculus and more extensively implemented during the 2004-2005 academic year.

## **Part 2: Identification of Need**

The three courses that comprise the Calculus sequence, MAT 136, MAT 137, and MAT 238, are offered every semester and together enroll approximately 450 students each semester. These courses are taken by students majoring in, among others, mathematics, physics, chemistry and engineering.

As in most mathematics courses, the key to students' thorough understanding of the concepts in calculus is for them to do many homework problems. That is they must practice, practice, practice to become full participants in their learning. Anecdotal evidence suggests that the time students spend on homework has been declining over the years. At the same time, educators agree that the more time students spend on trying to master the material covered in a course, the more likely they are to succeed in the course. While the well-motivated student will always do more problems than necessary, the typical student will put off this necessary practice until somehow motivated, most commonly by a test. However, doing many problems just before a test is not the best way to learn the material. We need to encourage students to be more fully engaged in learning on a regular basis and to take responsibility for their own learning.

Ideally, a professor would assign daily homework to be collected, grading every problem and giving the student the necessary feedback regarding their understanding of the material. In reality, problems are usually assigned daily but only a small percentage of problems can be checked for correctness. These might be returned several days later, with little feedback other than marks of wrong answers, and students are not given the opportunity to continue working on the problems they missed. That is, we are beginning a feedback loop, but the structure doesn't encourage the students to make use of this feedback to increase their mastery of the material. The situation is even further complicated by declining resources. Due to recent budget cuts our department can no longer support paper graders and thus more instructors are resigned to assigning homework without collecting and grading it. Thus students will not be getting the necessary feedback on their progress.

Since there is a need to give students feedback on their understanding of the material we propose using an on-line homework system to do this. WeBWork is an internet-based system for generating and delivering homework problems to students that provides immediate feedback and the opportunity to rework missed problems. The goal is to make homework more effective and efficient. WeBWork will increase the effectiveness of traditional homework as a learning tool by providing students with immediate feedback on the validity of their answers. It will also give students the opportunity to correct mistakes while they are still thinking about the problem. It will provide students with

individualized versions of problems which means that instructors can encourage students to work together and yet each student must develop an answer to his or her own version of the problem.

This method will increase the efficiency of traditional homework by providing automatic grading of assignments. It will also provide information on the performance of individual students and the course (or section) as a whole, to assist in the overall assessment of our Calculus sequence.

The current DFW rate for the Calculus sequence at NAU is approximately 33%, with Calculus I reaching approximately 37%. These percentages are far higher than we would like them to be. In addition, MAT 136 and MAT 137 (Calculus I and Calculus II) are among the “top 10” courses on our campus based on DFW rates. Thus there is a real need to address student performance in these courses, which is one of our reasons for choosing these courses to pilot the WeBWork program. If this pilot is successful then we can use this as a springboard to consider using WeBWork for other courses with high DFW rates, especially MAT 125 – Precalculus.

### **Part 3: Technical Needs**

WeBWork was developed (and continues to be developed) at the University of Rochester with support from the National Science Foundation. It is distributed freely. The major technical need in implementing WeBWork is faculty and systems analyst effort in installing, setting up and configuring WeBWork, adapting problem sets, and training faculty so that it may be used successfully.

With WeBWork, advanced mathematics problems can be authored, displayed and printed with typeset quality. It can handle most standard homework problems that are assigned in calculus courses, and comes with a Rochester library of problems. Professors can easily write their own problems (or edit library problems). WeBWork is currently in use by approximately 50 colleges, universities, and high schools.

WeBWork produces similar but individualized problems for each student. This makes WeBWork particularly effective in a group learning setting, since students can collaborate without copying. WeBWork remembers each student's problems, so they can connect to WeBWork, attempt a problem, receive immediate feedback about the validity of their answers, try again or logout and give the problem more thought if necessary, and then reconnect to WeBWork to attempt their own individualized problems again. Students can attempt a problem as many times as they wish until the due date unless the instructor desires to place a limit on the number of allowed attempts. Each problem in a set can have a different limit on the number of allowed attempts. For example, an instructor may wish to limit the number of attempts on T/F questions while allowing unlimited attempts on problems requiring numeric and symbolic answers.

Problem sets are graded automatically, and the resulting scores are easily exported to and imported from spreadsheet programs such as Excel. Much more detailed statistical information on the current progress of a class or an individual in completing any assignment is available.

Published studies tend to indicate that in courses using WeBWork student time on task is greater and student performance is higher than those in courses not using WeBWork.

The WeBWork program will be downloaded from the University of Rochester and initially put on an existing workstation in the Department of Mathematics and Statistics. This will suffice for the initial pilot in Spring 2004. It is our intention to apply to other sources for funding for a dual processor server to handle the load anticipated from the Fall 2004 implementation. There will also be modest needs for supporting software, media and supplies.

#### **Part 4: Work Plan**

The work for this project will begin in the Fall of 2003 and continue through June 2005 as outlined in Table I. Much of the work will be done during the regular academic year with the bulk of the compiling of problem sets and training modules to be done during the summer of 2004.

#### **Project Outline in Brief:**

**Fall 2003** – Preparation work; practice with WeBWork via the University of Rochester server. Submission of proposals to other sources for modest funding for a dedicated server for Fall 2004.

**Spring 2004** – Initial installation of WeBWork on existing server running Linux. Pilot of WeBWork in a few sections of Calculus II by Hagood and McShane.

**Summer 2004** – Installation of server (funded by other sources) and WeBWork on that server. Adaptation of problem sets for affected courses. Planning of training for faculty. Set up of courses on the server.

**Fall 2004** – Training of faculty. Use of WeBWork in several sections of Calculus I and II. Planning for the spring. Adaptation of problem sets for Calculus III.

**Spring 2005** – Evaluation of Fall 2004 use. Training of faculty. Use in several sections of Calculus I, II and III.

**Summer 2005** – Evaluation. Planning for the future. Submission of final report.

#### **Part 5: Key Personnel**

John Hagood is an Associate Professor in the Department of Mathematics and Statistics. He has been involved in numerous grant-supported innovations in teaching and course design including calculus reform, design of computer projects in a variety of courses, and use of computer visualization in instruction. He will contribute to the adaptation/design of problem sets, setup of courses on the server, and training of faculty.

([John.Hagood@nau.edu](mailto:John.Hagood@nau.edu), 928-523-6879)

Janet McShane is an Associate Professor in the Department of Mathematics and Statistics. As a member of the department for over 20 years, she has had much experience in teaching the Calculus sequence. Along with Hagood and others, in the mid-nineties, she produced numerous Calculus labs for Calculus I and II, many of which are still used in the calculus curriculum today. She will contribute to the adaptation/design of problem sets, setup of courses on the server, and training of faculty.

([Janet.McShane@nau.edu](mailto:Janet.McShane@nau.edu), 928-523-1252)

**Table I: Timeline of Activities**

<b>Date</b>	<b>Activity</b>	<b>Personnel</b>	<b>Hours</b>	<b>Resource</b>
Fall 03	Continued investigation of WeBWork including consultation with users	Hagood McShane Sonafrank	-- -- --	NAU
Jan 04	Install WeBWork onto Department Linux station	Sieben	12	NAU
Jan 04 – Jun 05	Provide technical assistance to grant team	Sonafrank	48	NAU
Jan 04	Attend WeBWork sessions at AMS/MAA Joint Meetings in Phoenix	Hagood McShane	3 3	NAU
Jan 04	Visit ASU Math Department to consult with current users John Jones and Matt Isom	Hagood Sieben	8 8	NAU
Feb 04	Test the local installation of WeBWork	Hagood McShane Sieben	8 8 8	NAU
Mar 04	Develop several homework problem sets for the second half of MAT 137 – Calculus II	Hagood McShane	16 16	NAU
Apr 04	Field test the use of WeBWork in two sections of Calculus II	Hagood McShane	16 16	NAU
May 04	Analyze the results of the pilot program	Hagood McShane	12 12	LCE Grant
Jun 04	Install WeBWork on new server	Sieben	20	LCE Grant
Jun 04	Develop homework problem sets for Calculus I and II (gathering and tying to sections, primarily from existing sources)	Hagood McShane	80 80	LCE Grant
Jun 04	Develop training module for faculty who will use WeBWork in Fall 2004	Hagood McShane Sieben	16 16 16	LCE Grant
Aug 04	Set up the courses for Fall 04	Hagood McShane Sieben	12 12 12	LCE Grant
Aug 04	Train faculty teaching Calculus I and II on the use of WeBWork	Hagood McShane Sieben	8 8 8	NAU
Fall Sem 04	Use WeBWork in Calculus I and II	Faculty teaching Calc I and II	64	NAU
Nov 04	Develop homework problem sets for Calculus III	Hagood McShane	24 24	NAU
Dec 04 Jan 05	Evaluate the results of WeBWork use in Fall 2004 and adjust accordingly	Hagood McShane	24 24	NAU
Jan 05	Set up the courses for Spring 05	Hagood McShane Sieben	8 8 8	NAU
Jan 05	Train faculty teaching Calculus I, II and III on the use of WeBWork	Hagood McShane Sieben	4 4 4	NAU
Spring Sem 05	Use WeBWork in Calculus I, II and III	Faculty in Calc I, II, III	80	NAU
May 05	Compile results of WeBWork use in relation to expected results and outcomes, plan for the future, expand to other courses or limit as indicated	Hagood McShane	24 24	LCE Grant
June 05	Final Report	Hagood, McShane	16 16	LCE Grant
		<b>Total Hours</b>	<b>838</b>	

Nandor Sieben is an Assistant Professor in the Department of Mathematics and Statistics. He is well versed in the Linux operating system. Nandor has worked with WeBWork expert John Jones at ASU on an on-line placement test using similar software. He will contribute to the technical aspects of the project.

([Nandor.Sieben@nau.edu](mailto:Nandor.Sieben@nau.edu), 928-523-6874)

Allen Sonafrank, Computer Systems and Network Manager for the College of Arts and Sciences, will serve as a consultant for technical issues. He has already contributed about 30 hours in the early stages of our investigation of WeBWork and will continue to advise the grant team for about an hour per week throughout the project. ([Allen.Sonafrank@nau.edu](mailto:Allen.Sonafrank@nau.edu), 928-523-8106)

### **Part 6: Expected Results and Outcomes**

There are six outcomes that we hope to accomplish with this project. They are (1) better student performance, (2) more time on task, (3) improved student satisfaction, (4) better quality grading, (5) monetary savings, and (6) assessment of feasibility for other courses.

(1) Better Student Performance

We hope that students will be more successful in the Calculus sequence and we will measure this by comparing the DFW rates in sections using WeBWork to baseline (last several years) rates.

(2) More Time on Task

During the Fall of 2003, before the piloting of WeBWork, students in two sections of MAT 136 will be asked to keep a log of the amount of time they spend on homework. During the Fall of 2004, when we are using WeBWork, we will again survey the students regarding their time spent on homework.

(3) Improved Student Satisfaction

We are interested in students perceived satisfaction with what they have learned in their calculus course. We will measure this by simply asking the students about their satisfaction level and asking them to rate factors that contributed the most to their satisfaction, such as homework, lectures, tests, study groups, etc.

(4) Better Quality Grading

We wish to achieve greater accuracy, faster response, and more opportunity for reworking missed problems.

(5) Monetary Savings

We are utilizing our first year GTA's to do some of the paper grading for the calculus sequence. They are grading a total of 21 hours per week, which is the equivalent of one GTA salary for one semester at a cost of \$6000. With WeBWork we could eliminate this amount.

(6) Assessment of Feasibility for Other Courses

We intend to assess the value of the system for use in other courses, especially MAT 125, by collecting faculty and student opinion.

Dissemination: We will report our results at state and regional mathematics meetings in 2005 in a form that will make it possible for other institutions to make use of our experience to implement WeBWork.