

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

Proposal Title: On-Line Homework to Improve Student Quantitative Reasoning

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

ASU East UA South

ASU West NAU

Briefly describe the program and the development plan.

This project proposes to improve student mathematical learning in the Liberal Studies Mathematics course MAT 114 – Quantitative Reasoning by using the WeBWork online homework system. Problems applicable to the material in MAT 114 will be written during the Summer of 2005 and then used in MAT 114 during the 2005-2006 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

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Signature: Roy T. St. Laurent

Official Authorized to Enter into Contractual Obligations

Signature: _____

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On-Line Homework to Improve Student Quantitative Reasoning

Part 1: Abstract

This project proposes to improve student mathematical learning in our general education mathematics course MAT 114 – Quantitative Reasoning by using the WeBWorK online homework system. Problems applicable to the material in MAT 114 will be written during the Summer of 2005 and then used in MAT 114 during the 2005-2006 academic year. It is anticipated that the use of an online homework system that provides immediate feedback and the opportunity to revise work will enhance student understanding of the mathematical concepts covered in MAT 114.

Part 2: Identification of Need

At Northern Arizona University, we are currently in the first stage of implementing WeBWorK, an online homework system developed at the University of Rochester, in our Calculus sequence. We are pleased with the initial results and feel that it would be a beneficial tool to use in MAT 114, one of our most populated courses, but have discovered a lack of appropriate yet challenging mathematical problems related to this course.

In 1999 Northern Arizona University completely revamped its Liberal Studies Curriculum. As part of this change, the mathematics course, MAT 114 – Quantitative Reasoning became the course targeted to satisfy the Mathematics Foundation requirement of the Liberal Studies Program. Currently this course is taken by those students whose major does not require a specific mathematics course. The course is offered every semester, including summers, with typically 28 sections and about a 1000 students each year.

We are presently in discussions with colleagues in two academic units that will likely result in MAT 114 being required by additional degree programs. When this happens we will offer an additional 12-15 sections of MAT 114 each year and the number of students enrolled in this course will increase to 1500 or more, which amounts to more than 40% of our freshman class. Thus MAT 114 represents a central entry level course at NAU.

In MAT 114, as in most mathematics courses, the key to students' thorough understanding of the concepts 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 want to encourage students to be more fully engaged in learning on a regular basis and to take responsibility for their own learning.

Ideally, an instructor 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. Therefore 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. 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, rework the problem or logout and give the problem more thought before attempting it again. 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. Using WeBWorK will increase efficiency 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 courses.

With funding from a previous LCE Grant (WeBWorK in the Calculus Curriculum (2004)) the department has begun using WeBWorK in our calculus sequence as well as some sections of precalculus and linear algebra. Initial reaction from both students and faculty regarding WeBWorK is very positive. Published studies tend to indicate that in courses using WeBWorK student time on task is greater and student performance is higher than in courses not using WeBWorK. Our surveys from our pilot sections during Spring 2004 and Summer 2004 tend to agree with these studies. We now wish to extend the use of WeBWorK to MAT 114.

WeBWorK was developed (and continues to be developed) at the University of Rochester with support from the National Science Foundation. It is distributed freely. 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 mathematics courses, and comes with a Rochester library of problems. However, the bulk of these problems cover topics in precalculus and calculus. There are very few problems that are suitable for use in a Liberal Studies course such as our MAT 114. Thus we propose to develop a library of problems to use in MAT 114.

Our course MAT 114 is often taught by our graduate teaching assistants who are beginning teachers and thus need extra mentoring with respect to their teaching. By developing a library of problems, subdivided into problem sets, we can help them in their development as teachers. We will employ graduate students over the summer to author and test problems. The authoring of problems involves the use of the computer language PERL and the typesetting program TeX, and requires a good bit of care and effort. The graduate students will be closely supervised by the faculty involved in the project to ensure the quality of the problems written. Using graduate students on this project will have numerous positive outcomes. First of all it will help them to develop a better understanding of the material to be covered in MAT 114. Second, it will give them practical experience writing suitable problems. Third, since many of our graduate students go on to teaching careers at the secondary and post-secondary level, this experience will expose them to innovations in the field of teaching mathematics.

As part of this proposal, we will also develop training materials to be used by instructional

faculty who will use WeBWorK during the 2005-06 academic year. Before the beginning of both the Fall and Spring semesters, we will hold training sessions for faculty and graduate students on the use of WeBWorK.

Part 3: Technical Needs

The WeBWorK program was initially set up on a server that already existed in the Department of Mathematics and Statistics. Through another grant we were able to purchase a new server dedicated solely to WeBWorK. This server is more than adequate to handle the additional demand for MAT 114.

The major technical needs in implementing this proposal consist of the following:

- Maintaining and upgrading the system
- Backing up the system regularly
- Making the new problems available for each course
- Troubleshooting
- Course setup each semester
- Upgrading to WeBWorK2 (at no cost)

The technical aspects of the proposal will be covered by Dr. Sieben and our technical staff.

Part 4: Work Plan

The work for this project will begin in the Spring of 2005 and continue through June 2006 as outlined in Table I. The bulk of the development will be done during the Summer of 2005, while the implementation will take place during the academic year.

Project Outline in Brief:

Spring 2005 – Analysis of MAT 114 curriculum. Development of training materials for graduate students.

Summer 2005 – Training of graduate students in use of WeBWorK and the authoring of problems. Authoring and testing of problems. Developing problem sets.

Fall 2005 – Training of faculty and graduate students. Use of WeBWorK problems sets in most sections of MAT 114. Evaluation of use. Make revisions as necessary.

Spring 2006 – Training of faculty and graduate students. Use of WeBWorK problems sets in most sections of MAT 114. Evaluation of use. Make revisions as necessary.

Summer 2006 – Evaluation. Planning for the future. Dissemination of problem library. Submission of final report.

Table I: Timeline of Activities

Date	Activity	Personnel	Hours	Resource
Apr 05 – May 05	Analyze current MAT 114 curriculum to determine a list of problem types to be modeled in the WeBWorK system	Hagood McShane Sieben	20 20 20	NAU
May 05	Develop documentation and training materials regarding the use of WeBWorK and specifics on authoring problems in WeBWorK	Hagood McShane Sieben	8 8 8	LCE Grant
Jun 05	Train graduate students in the use of the WeBWorK system and the authoring of problems in WeBWorK	Hagood McShane Sieben	8 8 8	LCE Grant
Jun 05 – Aug 05	Problem writing, testing of written problems	3 Grad Students	840	LCE Grant
Jun 05 – Aug 05	Overseeing problem writers, testing problems, testing logical syntax of problems, develop problem sets for use in Fall 2005	Hagood McShane Sieben	24 24 24	LCE Grant
Aug 05	System administration including set up of courses for Fall 2005, creating appropriate pdf files, writing scripts for transferring data	Sieben	30	LCE Grant
Aug 05	Train faculty and GTA’s teaching MAT 114 on the use of WeBWorK, develop instruments to collect appropriate data to evaluate WeBWorK use	Hagood McShane Sieben	4 4 4	NAU
Fall 05	Use WeBWorK in MAT 114 Coordinate use of WeBWorK in MAT 114	McShane	15	NAU
Dec 05 - Jan 06	Evaluate the results of WeBWorK use in MAT 114 in Fall 2005 and adjust accordingly	Hagood McShane Sieben	20 20 20	NAU
Jan 06	System administration	Sieben	30	NAU
Jan 06	Train faculty and GTA’s teaching MAT 114 on the use of WeBWorK	Hagood McShane Sieben	4 4 4	NAU
Spring 06	Use WeBWorK in MAT 114 Coordinate use of WeBWorK in MAT 114	McShane	15	NAU
April 06	Report preliminary results at MAA / ArizMATYC meeting	Hagood McShane Sieben	20 20 20	NAU
May 06	Evaluate results of WeBWorK use in relation to expected results and outcomes, plan for the future, dissemination of problems	Hagood McShane Sieben	14 14 14	LCE Grant
June 06	Final Report	McShane	20	LCE Grant
		Total Hours	1316	

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, use of computer visualization in instruction, and implementation of WeBWorK in calculus at NAU. He will contribute to the analysis of MAT 114, training of graduate students, supervision of graduate students, testing problems, and training of instructional faculty. (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 many years, she has much experience in teaching at all levels including MAT 114. She has been involved in numerous grant-supported innovations in teaching, design of computer projects in a variety of courses, use of computer visualization in instruction, and implementation of WeBWorK in calculus at NAU. She will contribute to the analysis of MAT 114, development of training materials, training and supervision of graduate students, problem testing, training of instructional faculty and oversight of the grant. (Janet.McShane@nau.edu, 928-523-1252)

Nandor Sieben is an Assistant Professor in the Department of Mathematics and Statistics. He has been involved in the implementation of WeBWorK in calculus specifically as the person in charge of the technical setup of WeBWorK on our server. He has also used WeBWorK in his Linear Algebra course and is proficient in PERL, the computer language on which WeBWorK is based. He will contribute to the technical aspects of the project, documentation and training materials, testing problems, supervision of graduate students and training of instructional faculty. (Nandor.Sieben@nau.edu, 928-523-6874)

Graduate students currently working toward an MS in Mathematics or Statistics will be hired to author and test problems and to develop problem sets in the WeBWorK system.

Part 6: Expected Results and Outcomes

There are seven outcomes that we hope to accomplish with this project. They are:

(1) A Problem Library for Quantitative Reasoning A library of problems suitable for MAT 114 will be developed and shared with the WeBWorK developers at Rochester for further distribution.

(2) Better Student Performance We hope that students will be more successful in MAT 114. We will measure this by comparing the pass rates in sections using WeBWorK to baseline (last several years) rates.

(3) Improved Student Satisfaction We are interested in students' perceived satisfaction with what they have learned in their MAT 114 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 expect to achieve greater accuracy, faster response, and more opportunity for reworking missed problems. The measure of success will be the number of sections that use WeBWorK and the extent of use in each section.

(5) Improved Understanding of Content of MAT 114 by GTA's A survey of present MAT 114 instructors not using WeBWorK and those using WeBWorK next fall will be used to compare GTA confidence level with the material.

(6) Professional Development of Future Teachers This will be indicated by the number of GTA's trained and given experience in the use of WeBWorK.

(7) Improved Learning Outcomes in MAT 114 Through the item analysis and record keeping facilities of WeBWorK we will be able to ascertain performance levels by topic and subtopic in MAT 114 and to respond accordingly by giving more attention to those topics in class and in training sessions for GTA's.

Dissemination: We will report our results at state and regional mathematics meetings in 2006 in a form that will make it possible for other institutions to make use of our experience to implement WeBWorK in a Liberal Studies Mathematics course.