

Learner-Centered Education Grants

2004 Final Report

1. Project Name and Project Director's Name. Include mailing address, phone and e-mail address.

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2. Brief Description of Project:

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

3. Goals, Outcomes and Assessments

a. Goals and Primary Accomplishments:

Our primary goal was to adapt and implement the WeBWorK online homework system in our calculus sequence. This entailed installing the system on our local server, learning how the system worked, and training faculty in its use.

b. Outcomes and Assessment for each Goal:

The desired six outcomes of the project were: (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. We will address each of these outcomes.

(1) Better Student Performance

Our hope was that by using WeBWorK, students in the Calculus sequence would be more successful. To assess this we focused on the grade distributions of the two faculty members who taught Calculus I and Calculus II both with and without WeBWorK during the 2003-2005 academic years. Data for their sections, summarized in the table below, show a definite decrease in DFW rates.

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DFW Rates				
	Fall 2003 Non WeBWorK	Fall 2004 WeBWorK	Spring 2004 Non WeBWorK	Spring 2005 WeBWorK
Calculus I	43%	30%		
Calculus II			35%	21%

(2) More Time on Task

In each section that used WeBWorK we administered a student survey that gave us some indication of the amount of time students spent on their homework assignments. (See Appendix A for the survey and Appendix B for the results of the survey.) The surveys for the Fall 2004 and Spring 2005 semesters state that students spent, on average 2.2 hours on their WeBWorK assignments as compared to 1.7 hours on a traditional homework assignment. On our survey we had the statement: *I spent more time on homework in this course because of the use of WeBWorK.* Of the calculus students surveyed, nearly half indicated that they spent more time on homework. Appendix C is a graph of WeBWorK usage for Spring 2005. It is apparent from this graph that students spent a significant amount of time on their WeBWorK homework.

(3) Improved Student Satisfaction

One of the advantages of WeBWorK is that students get immediate feedback on the validity of their answers and are then allowed to rework problems that are incorrect. In fact, students can attempt most problems an unlimited number of times until they get the correct answer. Most students really liked this feature. Of the 374 calculus students surveyed in the fall and spring semesters, 89% agreed or strongly agreed with the statement: *The immediate feedback on my work is valuable for learning.* Similarly 89% agreed or strongly agreed with: *The ability to rework problems contributed to learning.*

We also asked the students whether having numerous tries at a problem was a good thing or a bad thing and why. Their response overwhelmingly stated that this was a good thing (319 out of 374). More revealing however was their justifications as to why this was a good thing. One student's response was: *"This was a very good thing because it allowed me to work and rework problems until I got them correct which helped me to learn the material better."* Over and over the students reiterated these thoughts. In a traditional homework assignment the student would not know they were doing a problem incorrectly until their homework was returned which was often a few days after they had completed it. Using WeBWorK, the students immediately knew if their answer was incorrect, and if so, they could then immediately work on resolving the problem. This provided the opportunity to correct an error before it became a pattern.

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(4) Better Quality Grading

In a typical mathematics course, when a traditional homework assignment is made it is collected and graded. Thus students get some feedback on their work, but it is usually a number of days after the assignment is completed and usually just a handful of problems can be graded. Therefore students may get no feedback on much of their homework. Because WeBWorK automatically grades problems, the students get feedback on **all** of the problems that they are working and they get that feedback immediately. The student comments in our survey show that this really benefits the students as they do not continue to do problems incorrectly. If they encounter difficulty, they know that immediately and they can then get help from the instructor before the assignment is actually due.

One valuable feature of WeBWorK that we were unaware of before the project is each student's list of previously submitted answers that is available to the instructor. This allowed an instructor to see the nature of a student's error and focus help on that error.

(5) Monetary Savings

In the past few years the amount allocated to paper graders in our departmental budget has declined considerably. Although there was an initial (and actually ongoing) expense of a server to house the WeBWorK system, that amount is still considerably less than the corresponding amount that would be required to grade all the problems the students are completing using WeBWorK.

(6) Assessment of Feasibility for Other Courses

The faculty that have used WeBWorK during the past year have all been very positive about its value. Faculty noticed an increase in student's comprehension of the material and an increase in their homework scores. Based on this, the department submitted two more proposals to implement WeBWorK in other mathematics courses. Both of these proposals were funded and we are currently working on implementing WeBWorK in MAT 114 – Quantitative Reasoning (our liberal studies course), MAT 119 – Finite Mathematics, and MAT 125 – Precalculus.

4. Problems or Issues Encountered:

The problems we encountered were really very small and had to do with the typical things: installation of hardware, installation of software, and adjusting to the use of new software. Students learned how to use the system very quickly. The biggest difficulty for faculty was learning how to import class enrollment lists.

5. Conclusions, Recommendations and Future Directions:

The coordinators are very pleased with the results of the project. Since first learning about WeBWorK, a number of faculty members in the department had discussed trying to implement it here at NAU. With the funding we received from this LCE Grant we were able to do just that. When we see students now in office hours it is apparent from the questions they ask that they have spent a lot of time on their homework. Instead of a student coming in and saying "How do you do this problem?", they now say "I've tried this problem a number of times, and I think I have done it correctly but WeBWorK tells me I'm incorrect." They

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can then show us their work and together we can determine the problem. This really is a shift in the way that students approach homework.

For the future we plan to expand our use of WeBWorK at NAU and to consider how we might help others implement the system elsewhere.

6. Has this project led to sustainable change in your department/college? Describe:

This project enabled us to implement the use of WeBWorK in our calculus curriculum. Because of how well this was received by both students and faculty alike, we are now, as a department, implementing the use of WeBWorK in numerous other courses in our curriculum. The ongoing costs, primarily a server and faculty time, are manageable within our existing sources of funding and faculty support is very solid so there is every reason to expect that the project will be sustained and even extended in the future.

7. Impact:

a. Have other faculty been affected by this project? Yes No. If so, describe:

To date, 14 different faculty members have used WeBWorK in their courses. These include faculty at all ranks as well as teaching assistants.

b. Number of courses affected/involved.

The online homework system WeBWorK was used in 40 sections of 9 distinct courses: Calculus I, Calculus II, Calculus III, Precalculus, Topics in Calculus, Discrete Mathematics, Linear Algebra, Foundations of Mathematics, and Numerical Analysis.

c. Number of students affected.

In the calculus sequence that was the target of the grant, there were 557 students in sections that used WeBWorK. As mentioned above, WeBWorK was also used in sections of other courses, affecting another 568 students. Thus there were 1125 students who used WeBWorK during the 2004-2005 academic year.

8. Significant Outcome:

What was the most significant outcome based on learner-centered principles that occurred through your project?

The most significant outcome based on learner-centered principles that occurred through our project is that students are taking a greater responsibility for their own education. This was clearly evident in their statements on our survey. One student wrote: *"I figured out what I was doing wrong and learned how to do it right."* Another wrote: *"I could find my own errors."* These statements were indicative of many of the students feelings.

One student sums it up best: *"I've struggled with math my entire life. The feedback and format of WeBWorK helped me fix deficiencies in my algebra background and find mistakes I commonly make without getting frustrated and giving up. It's been the single most effective tool I've ever used and I'm not sure I would have gotten this far without it!"*

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Appendix A

Survey of WeBWorK Users Fall 2004 & Spring 2005

Because you have used WeBWorK in your course this semester the Department of Mathematics and Statistics would like your responses to the following questions.

Grade Level: (circle one) Freshman Sophomore Junior Senior Graduate

Major: _____

For Problems 1-11 circle the appropriate answer.

S – Strongly agree A – Agree N – Neutral D – Disagree SD – Strongly Disagree

1. I prefer doing WeBWorK homework to traditional homework.

SA A N D SD

2. The immediate feedback on my work is valuable for learning.

SA A N D SD

3. The ability to rework problems contributed to learning.

SA A N D SD

4. I had difficulty accessing the package.

SA A N D SD

5. Using WeBWorK helped my overall learning of the material.

SA A N D SD

6. I prefer traditional homework to WeBWorK homework.

SA A N D SD

7. I spent more time on homework in this course because of the use of WeBWorK.

SA A N D SD

8. The pressure to rework incorrect problems detracted from learning.

SA A N D SD

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9. WeBWorK was easy to use.

SA A N D SD

10. It was good to have a deadline for when the assignments were due.

SA A N D SD

11. Where did you usually use WeBWorK?

University Lab Dorm Lab Dorm Room Off Campus Home

12. In using WeBWorK, you had numerous tries at each problem.

(a) Was this a good thing or a bad thing? Why?

(b) Should the number of tries be limited?

(c) How many tries do you think should be allowed?

13. Explain any difficulty you had in accessing WeBWorK.

14. Approximately how much time did you spend on each WeBWorK homework assignment?

15. Approximately how much time do you spend on a traditional mathematics homework assignment?

16. If you used WeBWorK in a previous semester, how has your opinion changed, if at all?

17. Any suggestions on how WeBWorK should be used in other semesters?

18. Any other comments?

THANK YOU!!

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Appendix B
Results of Survey of WeBWorK Users
Fall 2004 & Spring 2005

Below are the results of the WeBWorK survey that was administered to calculus students during the Fall 2004 and Spring 2005 semesters.

S – Strongly agree A – Agree N – Neutral D – Disagree SD – Strongly Disagree

1. I prefer doing WeBWorK homework to traditional homework.	SA	A	N	D	SD
	129	114	58	46	27
2. The immediate feedback on my work is valuable for learning.	SA	A	N	D	SD
	177	144	32	13	8
3. The ability to rework problems contributed to learning.	SA	A	N	D	SD
	201	130	20	13	10
4. I had difficulty accessing the package.	SA	A	N	D	SD
	6	19	64	177	108
5. Using WeBWorK helped my overall learning of the material.	SA	A	N	D	SD
	65	163	90	37	16
6. I prefer traditional homework to WeBWorK homework.	SA	A	N	D	SD
	37	57	79	116	84
7. I spent more time on homework in this course because of the use of WeBWorK.	SA	A	N	D	SD
	58	108	102	71	33
8. The pressure to rework incorrect problems detracted from learning.	SA	A	N	D	SD
	12	49	59	165	89
9. WeBWorK was easy to use.	SA	A	N	D	SD
	95	186	60	27	5
10. It was good to have a deadline for when the assignments were due.	SA	A	N	D	SD
	83	200	55	23	7

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Appendix C

