INTER-CAMPUS IMPLEMENTATION OF WEBWORK

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ABSTRACT. In this paper, we report on our experiences implementing WeBWorK at the University of Michigan-Dearborn in collaboration with WeBWorK expert Gavin LaRose on the main campus in Ann Arbor. This efficient and cost-effective model, centered on an expansion of WeBWorK from an already successful program on a main campus to a new implementation on an auxiliary campus, could be replicated in other university systems. We offer this paper as a blueprint (or cautionary tale) for anyone planning to implement WeBWorK with similar resources. Two quantitative measurements of enhanced student engagement and improved academic performance are given.

1. INTRODUCTION

In this paper, we report on our implementation of WeBWorK in the introductory curriculum at the University of Michigan-Dearborn, located in metropolitan Detroit. WeBWorK is an online homework system developed at the University of Rochester by Gage, Pizer, and Roth and supported by the National Science Foundation and the Mathematical Association of America. Our implementation of WeBWorK during 2010 - 2013 was an inter-institutional collaboration between the Dearborn and Ann Arbor campuses of the University of Michigan.

The Ann Arbor campus has had a very successful WeBWorK program for a number of years, and began to remotely host the Dearborn WeBWorK sites on its servers in 2010. Remote hosting in Ann Arbor removed for us all of the technological barriers commonly faced by departments aiming to implement WeBWorK, and was an important step in our implementation.

Our goals with the implementation were to improve student learning, increase student retention, enhance student-student and student-faculty interaction, deepen academic excellence, improve students’ problem solving and communication skills, engage students with active learning, prepare our students to enter the workforce, and decrease fail rates.

We begin in Section 2 with a description of WeBWorK and its benefits for student learning. In Section 3 we present a brief profile of the University of Michigan-Dearborn and its Department of Mathematics and Statistics. The main steps in the implementation are detailed in Section 4. We reflect on some of the main challenges we encountered in Section 5. Our rationale behind the expected outcomes is sketched in Section 6, where we also describe a potential study to verify if the expected outcomes
in the areas of engagement and achievement have come to fruition. We finish up in Section 7 with a discussion of the impact and relevance of our implementation.

2. **WeBWorK**

2.1. **What is WeBWorK?**. WeBWorK is an online homework system developed at the University of Rochester by Michael E. Gage, Arnold Pizer, and Vicki Roth. The project began in 1996, and has been continually improved with National Science Foundation grants since then. Recently, the Mathematical Association of America was awarded a large NSF grant to expand WeBWorK and provide it with a permanent supportive home.

WeBWorK has many wonderful features. Problems are individualized, so that different students have similar problems with different numbers. There is great versatility in the kinds of questions posed and the kinds of answers: numbers, vectors, functions, units, integrals, and so on. Typically, students enter answers using calculator syntax, and use the preview function to convert the calculator syntax into usual math notation and catch typos before submission. WeBWorK immediately gives feedback to students on answers, while the problem is fresh in their minds. Multiple tries are allowed, the exact number of which is determined by the instructor. The national library has over 20,000 problems ranging from College Algebra through Linear Algebra, Complex Analysis, Statistics, Probability, and more, though certain topics have more coverage than others. Faculty can compose their own problems or customize existing problems.

WeBWorK requires no software beyond an ordinary web browser, once it is set up on a server. The software was developed by faculty for faculty, and is open source, completely free. The software enables instructors to see students' progress in real time, meaning an instructor can log on to WeBWorK and see exactly which problems which students have solved or attempted. This data enables faculty to structure their teaching around student needs. WeBWorK is textbook independent, as the problems are organized according to topic. The software can be used for more than just homework, for instance gateway exams, diagnostic exams, or even placement exams are possible applications.

2.2. **Benefits of WeBWorK to Undergraduate Learning.** The literature on WeBWorK effectiveness continues to develop.

A 2001 study by Hirsch–Weibel at Rutgers, see [10] and [11], found that general Calculus sections using WeBWorK performed 4% better on the common final exam than non-WeBWorK sections. The gains became much more pronounced when the authors distinguished between students in WeBWorK sections who actually did the WeBWorK and those who did not, rather than distinguishing between WeBWorK sections and non-WeBWorK sections. First year students who attempted most WeBWorK problems had a final grade of B, while those who did not attempt many problems earned a D. The analogous difference for upper class students taking Calculus for the first time was even more dramatic: those who attempted most WeBWorK problems had a
final grade of B, while those who only did a few problems earned an F. Unfortunately, upper class students repeating Calculus showed no correlation between WeBWorK effort and final grade.

The benefits of WeBWorK are compounded when WeBWorK is combined with in-class interactive problem solving sessions. Dedic–Rosenfield–Ivanov considered linking lectures with three different homework modes in a social science Calculus class: 1) written homework graded by humans, 2) WeBWorK homework, or 3) WeBWorK homework coupled with in-class problem solving sessions. The purpose of the in-class problem solving sessions was to provide teacher and peer support in solving WeBWorK problems. In 2007 and 2008, Dedic–Rosenfield–Ivanov reported in [2] and [3] that students in group 3) far outperformed the other two groups in every measure: knowledge, final grade, percentage of correctly solved problems, frequency of assignments handed in, and likelihood of taking further math courses. Surprisingly, students using mode 3) also posed more questions to the instructor and sought more help outside of class. In view of the similar results of the graded groups 1) and 2), Dedic–Rosenfield–Ivanov remark that WeBWorK alone is not enough to improve student achievement.

Several studies present striking evidence for outstanding student perseverance with WeBWorK. Hirsch–Weibel found in [10] and [11] a surprisingly high correlation between attempts and percentage of problems solved, namely .944. In other words, students who attempted a problem typically persisted until they solved it correctly. In 2002, Gage–Pizer–Roth similarly reported in [5] that nearly all of their students at the University of Rochester persevered and completed nearly all of their homework correctly. Denny–Yackel also found at Mercer University that students attempt WeBWorK problems at a very high rate, see [4] from 2005. A motivating factor appears to be that students know every problem will be graded.

LaRose further confirms persistent student effort on graded WeBWorK assignments at the University of Michigan. In his 2010 article [7], LaRose investigated the effects of replacing ungraded written homework with graded and ungraded WeBWorK in a Calculus II course. He found that students gave increased attention to the homework when it is included in the course grade, and that there is some evidence this increased attention results in better understanding. Students in sections with online homework consistently did better on exams and gateways, however the differences on two of the three test exams were not statistically significant. Another finding LaRose documented is that students spend more time on the homework, complete a larger percentage of it, and have a more positive opinion of it, when homework is part of the course grade. Instructors surveyed by LaRose also indicated that WeBWorK allowed them to spend more class time on new material and less time on review.

An AMS Task Force also recommends online homework. In the 2010 summary of the AMS Homework Software Survey [6], Kehoe writes “An AMS Task Force believes that the use of software to help grade homework and tests has the potential to improve student learning in freshman mathematics mathematics courses...” Many departments across the nation also seem to think so: 76% of the 467 departments...
surveyed responded that “better learning” was a major issue in motivating the use, or prospective use, of homework software. The full report is available at [1].

WeBWorK also helps instructors to implement many of the recommendations in a recent U.S. Department of Education Practice Guide [8], such as “spaced learning”, connecting abstract and concrete representations of concepts, using quizzes to promote learning, and assisting students in identifying material they need to practice more.

3. INSTITUTIONAL AND DEPARTMENTAL PROFILE

3.1. University Profile. The University of Michigan-Dearborn is a comprehensive university located in metropolitan Detroit. It offers bachelor’s and master’s degrees in arts and sciences, education, engineering, computer science, and management. Recently, the College of Engineering and Computer Science, and the School of Education, both instituted PhD programs. Currently, there are approximately 9,100 students enrolled at the University of Michigan-Dearborn, of which 81% are undergraduates. Since its founding in 1959 with a generous gift by Ford Motor Company, the university has grown significantly.

The primary emphasis of the University of Michigan-Dearborn is undergraduate education. This university serves southeastern Michigan, and is responsive to the challenges the region currently faces. The university attracts many strong students; it has the 4th most rigorous undergraduate admissions in the entire state of Michigan. Half of the current students came directly to the University of Michigan-Dearborn after high school, while the other half transferred to the University of Michigan-Dearborn from community colleges or other local universities in the metropolitan Detroit area.

The University of Michigan-Dearborn is a public institution, though less than 20% of its funding comes from the state. The appropriation in the state budget for the University of Michigan-Dearborn is completely separate from the appropriations of the Ann Arbor and Flint campuses.

3.2. Department Numbers and Student Support. The Department of Mathematics and Statistics at the University of Michigan-Dearborn has 22 professors, 5 full-time lecturers, and 13 part-time lecturers. For the past several years, the number of math majors has hovered around 120. In the 2012-2013 academic year, there were 2,722 enrollments in the introductory classes Precalculus - Linear Algebra (this count does not include the Algebra, nor Conceptual Math, where WeBWorK was not implemented). All Precalculus and Calculus classes have a maximum size of 32 students.

The department offers two support systems for students. The Math Learning Center, staffed by many math and engineering majors, offers free walk-in tutoring service 45 hours each week. Importantly, the Math Learning Center has computers, so students can work on WeBWorK there. Some introductory classes also have a “student mentor”, who is typically an advanced math major. The “student mentor” helps facilitate in-class group work, assists in computer labs, holds office hours in the Math Learning Center, and simultaneously learns pedagogy from the faculty member in class.
4. THE IMPLEMENTATION

The implementation of WeBWorK on the Dearborn campus had several key steps: server hosting in Ann Arbor, a pilot, a faculty survey, faculty training, and student support via the Math Learning Center and “student mentors”. Several of these steps happened slowly and deliberately in order to build as much faculty support as possible.

4.1. Server Hosting on the Ann Arbor Campus. At the request of present co-author Mahesh Agarwal, a handful of UM-Dearborn pilot WeBWorK sites were set up in Ann Arbor by Gavin LaRose in 2010. Over the years, the number of sections hosted in Ann Arbor has grown. The local expertise and technology on the main campus essentially meant the biggest obstacle to implementation was already overcome: we did not need to procure or maintain servers and install WeBWorK because Ann Arbor already had its servers up and running. This aspect of our implementation, namely a branch campus utilizing existing WeBWorK resources on the main campus, could be replicated in other university systems across the nation. With increased access to cloud computing and remote hosting, even campuses without similar resources could hopefully implement WeBWorK without huge economic costs. The Mathematical Association of America (MAA), as of the writing of this article, remotely hosts institutional pilots of WeBWorK on its servers.

4.2. WeBWorK Pilot at the University of Michigan-Dearborn. For three semesters (Winter 2010-Winter 2011), Mahesh Agarwal organized a WeBWorK pilot in the Department of Mathematics and Statistics in Dearborn. Roughly one-third of the faculty enthusiastically participated in the pilot, with courses ranging from Pre-Calculus to Linear Algebra. There was tremendous variability in faculty usage during the pilot. A few faculty members made homework sets for each chapter in their course, many others had only one or two assignments, and still others used WeBWorK only for the Gateway exam in the Math Learning Center. Nearly all of the pilot participants were full-time faculty.

Feedback from the faculty was quite positive, but not entirely. Several faculty members said they need more training and assistance. Others indicated that common assignments across sections are a very efficient goal, since searching the national library and making a well-balanced assignment every week was far too time intensive for each faculty member. Faculty members teaching more advanced courses such as Differential Equations or Linear Algebra had hoped for more problems in the national library at that time. Another faculty member pointed out that some of the routine, computational problems could be solved using other web-based resources, such as Wolfram Alpha. Despite these reservations, WeBWorK still offers one of the most diverse question formats.

4.3. Gateway Usage during the Pilot. A few comments on Gateway usage during the pilot are also in order. A Gateway exam is a 20 or 30 minute exam which tests certain basic skills, and can be repeated as many times as a student needs within a two
week period to pass it with a near perfect score. The purpose of the gateway is: 1) to provide a snapshot of student skill level on material prerequisite to the present class, 2) to inform the instructor and the student of deficiencies before going forward, and 3) to ensure that as many students as possible have mastered the basics. Our Calculus I (Math 115) classes have two Gateways: the first tests Algebra in the first week, and the second tests derivative rules. Our Calculus II Gateway exams test derivatives and integrals. The reasoning behind Gateway exams is that students are more likely to go back and re-study the material when they have the opportunity to repeat the exam after an initial failure. The built-in tutorial in the Michigan WeBWorK Gateway is very helpful in this regard.

Before the pilot, UM-Dearborn students were taking proctored Gateways on commercial software in the Math Learning Center. This resulted in better student learning, but administration was complicated because new passwords were generated every semester, students often forgot or lost passwords, and students had to learn an unfamiliar system. The pool of questions was narrow, and the problems were not randomized. During the pilot, Gateways were administered on WeBWorK in the Math Learning Center, following the model in Ann Arbor. This was a huge simplification, since the logins are the same as the university logins, and students are already familiar with the system from their homework. Also, students can practice randomly generated Gateway exams at home on WeBWorK. Importantly, students are familiar with the system, there is variety of questions, and the practice exams are self-graded with built-in tutorials.

4.4. Student Feedback on WeBWorK Pilot at UM-Dearborn. The student feedback on the pilot was very compelling, or at least compelling enough to continue the implementation.

- “I liked that we were given points for homework. It gave me the incentive to get it done and to do it right. This made me study the material more as well.”
- “The questions were hard, but that is good practice for test questions.”
- “It gives us practice, and we get points for it, so it’s sort of a double reward...A lot of us have hectic schedules, so getting points for it is really helpful.”
- “Assigning homework on-line made it much easier to keep up in studying and knowing the material.”
- “I liked WeBWorK because it helped me learn better than just doing problems from the book. This is because it gave me several tries instead of just getting back incorrect homework.”
- “The syntax of WeBWorK makes it difficult for me.”
- “I liked doing the homework online, with instant feedback.”
- “I liked ... the number of tries you get to do the problem.”
- “I really like it, some of the questions were challenging to me, but in the end, I get them all.”
- “I like that I am able to do WeBWorK online because it is accessible anywhere.”
- “WeBWorK helped me to stay on track and keep up with work.”
• “I liked the fact that we could work on the problems together to get the basic understanding of the problem, and then we have to go and evaluate it with our own numbers.”
• “I didn’t like that it was worded differently than in class.”
• “The fact that we do not have to show work makes it hard for us to tell whether we showed enough work on the test.”

4.5. Fall 2012 WeBWorK Survey of Faculty. In Fall 2012, present authors Thomas Fiore and Mahesh Agarwal conducted a survey of faculty attitudes, beliefs, and usage concerning WeBWorK. There were 19 respondents amongst the entire full time faculty, part time faculty, and recent retirees (40 people). Three of the invitees were brand new assistant professors, so had not yet used WeBWorK in the department.

Amongst the respondents, some trends emerge, despite the low participation. For instance, among the respondents who indicated attitudes and beliefs, it is clear that the vast majority “strongly agree” or “agree” with the many reasons Fiore and Agarwal often cite in favor of WeBWorK, such as 1) students learn mathematics when they solve problems independently and when they discuss homework, 2) students learn more from homework when they have immediate feedback and can retry a problem, 3) average UM-Dearborn students are less likely to do homework when they know it will not be collected and will not count towards the grade, 4) students do better on exams when they do homework, and 5) students should learn to persevere, look back, and correct their work. Also, 11 of 14 respondents intend to use WeBWorK in the future for homework assignments, while 7 of 13 intend to use it for Gateways.

4.6. Training and Supporting Faculty. The training and support of the faculty (especially part-time faculty) was a crucial part of this implementation. From 2010 to 2013, we offered WeBWorK training workshops to faculty at the beginning of Fall and Winter semesters. We also gave several colloquium presentations about the system and its benefits. In addition to the workshops, we offered trouble-shooting help throughout the semester, since minor issues always arise. Despite our efforts, we did not reach all faculty.

4.7. Supporting Students. The two primary sources of student support (the Math Learning Center and student mentors) needed some preparation for the initial spike in demand. Early in the implementation, Mahesh Agwarwal tutored some of the Math Learning Center tutors and student mentors on how to use WeBWorK. Nowadays, this extra preparation is no longer necessary, since by now most of the tutors and student mentors have learned WeBWorK in their own classes. Tutors often help with syntax in the beginning of the term, but soon learners overcome the syntax issues and focus questions on the actual mathematics.

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1WeBWorK has various features to help deal with syntax issues. For instance both the preview button and answer correction provide feedback on syntax. Students also receive electronic solutions to their individualized Gateway exams in order to prepare for the next attempt.
After all these foundational steps in the implementation, there is still some regular maintenance to be done: introducing new faculty to the system, periodic reminders for faculty about how to turn on Gateways and how to download scores in a spreadsheet, etc.

5. Reflection on Unresolved Challenges in the Implementation

We next reflect on several challenges we encountered, and some partial resolutions. Anyone who wishes to implement WeBWorK is likely to encounter these challenges.

The first challenge is arranging adequate support for students in evening classes, especially Pre-Calculus and Calculus I students. Several of these students are only on campus in the evening, and hence cannot utilize tutoring in the Math Learning Center or office hours. Some of these students are particularly at risk, since they have not had math classes for several years and are unfamiliar with “calculator syntax”. One proposal was to offer interactive evening sessions on the computers in the Math Learning Center (see the discussion of [2] and [3] in Section 2.2 in connection with effectiveness of interactive sessions). However, extra evening sessions would have required extra funding and flexible student schedules, neither of which were available. Another proposal to support evening classes was to offer online tutoring via the chat function in a learning management system such as CTools or Canvas. A third proposal was to have students write-up some current solutions on the board before class and discuss them in the first minutes of class, with live feedback from the instructor. Another challenge similar to evening classes was general WeBWorK support during the summer, when there is a reduced faculty presence.

A second major challenge was the construction, maintenance, and improvement of problem sets. Given the tremendous demands on faculty time, it was simply impossible to continually improve WeBWorK sets for the entire introductory curriculum without multiple course releases. In our limited time, we built some of our own problems sets and obtained others from colleagues at other universities, but some tailoring is still needed. A fantastic resource for instructors looking for ready-to-go course problem sets is the MAA Model Course website.

http://webwork.maa.org/wiki/Model_Courses#.U53jfSgUpfg

Several standard courses have well-written and beautiful problem sets ready for immediate download and use. We will start experimenting with these in Fall 2014.

Another major challenge is the inherent tension between uniformization and individual preferences. Uniform homework sets across all sections bring advantages and efficiency: all students can be expected to know the same topics, there is no duplication of faculty maintenance work. On the other hand, some faculty feel that any requirement to use anything specific beyond a textbook is an unwelcome intrusion. Our best effort to resolve this dilemma was to build as much faculty consensus as possible before and during the implementation. This consensus building involved the pilot, department colloquia and discussion about the pros and cons of the WeBWorK system, a faculty survey, and many individual conversations. In the end, however,
several faculty members opted not to use the WeBWorK system, a prime reason being the unfinished form of the problem sets. We hope that the MAA model courses will help in this regard. A positive trend was that all recent hires elected to use the WeBWorK system, especially those who had WeBWorK experience during their post docs.

6. Rationale for Our Expectations, and Future Study

6.1. Rationale. With WeBWorK we expect to increase retention rates by ensuring student success in introductory math classes. To do this, WeBWorK offers instant feedback on homework, it encourages students to do homework well, and it enables the instructor to more closely monitor student effort on homework, thus allowing early identification of students at risk of failing.

WeBWorK enhances student engagement because students have much more incentive to discuss homework with classmates and faculty. They know homework is graded and counts as part of the grade. They also know where their mistakes are, so they can correct them before the due date. Student questions in office hours are much more focused: rather than declaring “I don’t understand that concept”, they ask “How do I do this particular step on a problem I have already mostly solved?” Some data support the idea of WeBWorK increasing student engagement: in 2010-2011 there were 10,500 distinct visits to the Math Learning center, while in the subsequent year 2011-2012, when a substantial number of sections began using WeBWorK, there were 14,000 distinct visits. In other words, there was a 33% increase in Math Learning Center visits after WeBWorK was introduced.

WeBWorK deepens academic excellence because students persist and practice much more on WeBWorK than on superficially graded written assignments. With a solid foundation in prerequisite courses, students are more likely to pass subsequent courses. WeBWorK emphasizes both problem solving and basic skills. Some recent Derivative Gateway Exam data from our implementation support the hypothesis that WeBWorK deepens academic excellence. In the 9 sections of Calculus I (Math 115) that offered the WeBWorK Derivative Gateway in 2013, merely 35.56% of the students passed on the first attempt, while 84.94% of the students passed after multiple attempts. Our reasons for looking into data for the Math 115 Derivative gateway are: i) it is offered towards the middle of the semester, by that time the students know proper “calculator syntax”, ii) it is not multiple choice, the students need to write serious formulas, iii) students have not been exposed to a similar gateway before, and iv) students can practice the gateway. The data also says something about the gains

\[ \frac{69}{194} = 35.56\% \]
\[ \frac{163}{194} = 84.94\% \]

Students who scored 0 are not included in the computations, as it is possible and likely such students dropped the course. We believe it is likely that the percentage of passes on the first attempt without practice at home would actually be lower than 35.56%.

\[ ^{\text{2Passing the Derivative Gateway means a score of } 5/7 \text{ or better. The figure for passing on the first attempt was } 69/194 = 35.56\%, \text{ while the figure for passing after multiple attempts was } 163/194 = 84.94\%. \text{ Students who scored 0 are not included in the computations, as it is possible and likely such students dropped the course. We believe it is likely that the percentage of passes on the first attempt without practice at home would actually be lower than 35.56%.}} \]
WeBWorK prepares students for a changing economy. WeBWorK, especially when embedded into the classroom discussion, improves communication, teamwork skills, problem solving, and math knowledge. Whenever students use math in today’s economy, computers are often involved. WeBWorK trains students to enter math into a computer in “calculator syntax,” which is an important skill for employment. Even simple spreadsheet manipulations require “calculator syntax”.

WeBWorK contributes to cost-savings and efficiency. By enhancing student engagement and deepening academic excellence, student learning becomes more efficient, and fewer students must repeat courses. This saves students money, at no additional cost, since WeBWorK is free for them. Also, students are more likely to succeed in subsequent courses, so they are more likely to graduate. The automatic grading of homework gives instructors more time to focus on other parts of the course with a greater impact.

6.2. Study. In the future, we hope to do a comparative study of student engagement and achievement, confirming the studies of Dedic–Rosenfield–Ivanov in [2] and [3] summarized in Section 2.2. The homework modes in math classes at UM-Dearborn currently naturally fall into three categories (according to instructor preferences): 1) written homework occasionally spot-checked by humans, 2) graded WeBWorK homework with optional written homework, or 3) graded WeBWorK homework coupled with in-class problem solving sessions and optional written homework. We propose to uniformly measure the engagement and achievement in all three categories in areas such as attendance mid-semester and the last week of the semester, number of times students pose questions, number of times students speak in class, final grades, and performance on a few common exam questions.

Importantly, we would also measure how faculty and students perceive their own engagement with tailor-made surveys. Sample engagement questions we could ask students are: how many times did you speak during the last class period? How many times did you personally speak to your professor this semester? What percentage of classes did you attend? Did you attend during the last week of classes? Does your instructor personally know you? How many times did you discuss math homework with classmates?

We expect that students in category 3) will have noticeably higher engagement and achievement, while category 2) will have only slightly higher engagement and achievement than 1).

7. Wrap Up

Computerized homework is consistent with the nature of 21st-century students: this new generation of students is spending more and more time online. On the one
hand, computerized homework harmonizes with students’ affinity for computers. But on the other hand, computerized homework can be built into the course structure in such a way to encourage teamwork and verbal, face-to-face interaction (e.g. student board presentations of WeBWorK problems). WeBWorK interfaces with technology in another way as well: textbook independence means that WeBWorK can be used with free, open access textbooks, such as those available through the Open Textbook Initiative of the American Institute of Mathematics (AIM).

http://aimath.org/textbooks/approved-textbooks/

Free open textbooks in tandem with WeBWorK alleviate student concerns about rising textbook prices and rising electronic homework prices[^4]. In fact, in Fall 2014 we will pilot the open access AIM approved textbook [^9] in tandem with the MAA model course for Differential Equations.

We have already mentioned other relevant aspects of our WeBWorK implementation. There is a clear need for more feedback on student homework in introductory courses in order to decrease fail rates, and at the same time increase student retention. WeBWorK provides this feedback automatically. At any non-residential university, there is always a need to enhance and cultivate student engagement. WeBWorK gives students more incentive to engage in discussion and learning with fellow students and faculty. WeBWorK also helps to prepare the workforce for a changing economy in which the interface between computers and math is becoming more and more important. During these years of very tight budgets, there is a drastic need for the universities to be more efficient.

A side benefit of our implementation was a stronger STEM Education community. First of all, the close collaboration with Gavin LaRose strengthened the ties between the Ann Arbor campus and the Dearborn campus of the University of Michigan. Another way in which our implementation built community was simply through close cooperation and collaboration between part-time and full-time faculty within our department. A third kind of community building was the “pollination effect”, which was an expansion of the WeBWorK community to more institutions. Namely, several UM-Dearborn part-time faculty work at other institutions as well, so their WeBWorK expertise enters other departments as well.

In the long term, we hope to continue to grow and improve our WeBWorK program.

REFERENCES


[^4]: From conversations with students, we have learned that many other introductory classes are using fee-based electronic homework, such as physics, chemistry, Spanish, and others. One student remarked: “$50 is a lot of money just to do your homework in a class.”


[10] Chuck Weibel and Lew Hirsch. WeBWorK effectiveness in Rutgers calculus. [http://www.math.rutgers.edu/~weibel/ww.html]