The Effects of Online Homework in a University Finite Mathematics Course
Preliminary Report

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Over the past 15 years, mathematics departments at colleges and universities have begun to incorporate the use of online homework systems in a variety of lower-level mathematics courses. Several online or web-based homework systems exist, including WebAssign, MyMath, DRILL, and WeBWorK, and most have been developed by textbook companies for use in introductory college-level mathematics courses. Web-based homework systems typically allow the instructor to create homework sets from a list of problems that have been pulled from the textbook. While all students typically receive the same set of problems, the numbers present in the problem will typically be randomized for each student (Denny & Yackel, 2005). The instructor may limit the number of attempts the student will be allowed on each problem and can specify the amount, and type, of feedback the student receives after an incorrect attempt. Typically, the numbers within a given problem are randomized so that different students will be working slightly different exercises. Overall, the purpose of the online homework system is to provide students with multifaceted, technology-based opportunities, rich with immediate feedback, to engage with course material outside of class.

Several studies have found that online or web-based homework systems effectively promote engagement with course material and may result in gains in both knowledge and skill, as they are measured inside the classroom. Denny & Yackel (2005) found that students attempt online homework problems at very high rates and their increased practice may translate into greater content-related knowledge and skill. Zerr (2007) found that by providing students with detailed feedback for incorrect responses when using the online system, and allowing several attempts for successful completion of each online assignment, that student learning in an introductory calculus course improved. When students are allowed several attempts at answering a question, without penalty, they may develop the tenacity required to solve more complex problems (Denny & Yackel, 2005). Moreover, the participants in Zerr's (2007) study overwhelmingly indicated that they felt their time spent using the online homework system was productive and worthwhile.

Web-based homework systems may not work equally well for all students, in all mathematics classes, however. Hirsch and Weibel (2003) found that the effectiveness of online homework greatly depended on the number of problems that students attempted; the more problems attempted the more correct answers students were able to provide. Zerr (2007) also noted that web-based homework systems may be most beneficial for students without prior college experience. Students with prior college experience using a web-based homework system actually tended to perform more poorly on exams and quizzes than students completing homework in a more traditional format (Zerr, 2007). The fact that students have occasionally been found to have lower performance when engaging with web-based homework systems may be accounted for, in part, by the fact that with web-based homework systems there is little opportunity for instructors to provide students with the tools they need to further their conceptual understanding of topics (Hauk & Segalla, 2005). On web-based homework, students will not receive credit based on work shown or not shown. When the work for a problem is not examined or graded by an instructor, it might be difficult for an instructor to pinpoint the conceptual issues a student is having. And, many instructors in mathematics would agree that an emphasis of product over process is

misplaced. When a student performs poorly on an online homework assignment, it would likely be the student's responsibility to seek out the instructor's expertise since the instructor need not be a part of the homework feedback loop if a web-based homework system is in use. In this way, online homework systems may actually inhibit collaboration between students and instructors. Hauk and Segalla (2005) found no significant difference between the performance of web-based and traditional homework sections of students taking college algebra. Moreover, web-based homework systems may do little to challenge the commonly-held notion that mastery of college-level mathematics involves little more than rote computation (Hauk & Segalla, 2005).

There are aspects of web-based homework systems that make them very attractive for instructors and administrators. From the instructor's perspective, they spare the teacher the time and tedium inherent in collecting and grading paper-based homework (Denny & Yackel, 2005; Hauk & Segalla, 2005). In addition, these online tools can be programmed to prompt students who have answered a question incorrectly to 'watch' a similar problem be worked through online or to look at a certain example in the text that will provide some guidance on the problem. In effect, online homework students may save the instructor some of the time and effort they typically exert in addressing students' more basic questions about course content (Hauk & Segalla, 2005). Meanwhile, administrators may appreciate the online system since it means they will not have to hire graders, and such systems may be perceived by students as an appropriate and forward-thinking use of technology. In addition, the cost of the product is paid directly by the student.

Even though colleges and universities have been using web-based homework systems in introductory mathematics classes for more than a decade, consensus has yet to be reached on how, or even whether, web-based homework systems compare to that of more traditional approaches in facilitating student learning outcomes. Although some researchers have found benefits for both students and instructors using web-based approaches, others have found none; hence, questions remain concerning the effectiveness of such a tool. It is possible students using an online homework system are not encouraged to be systematic in their approach to problems, as written evidence of their process is not required when using an online homework system. Moreover, if students are not thoroughly documenting the process used to solve a problem, they will not be able to use their work as a study prep. Nor would they readily and easily be able to communicate with their instructor about the difficulties they are having either in computation, process, or conception. A final cause for concern not already addressed in the literature is the student's awareness of their level of understanding of the material. Allowing a student multiple attempts on online homework problems is valuable in that it allows students the opportunity to immediately learn from their mistakes, correct themselves, and be rewarded for this effort. This often means the students' online homework scores are quite high (90% and higher is common). Is it possible that, as a result of high on-line homework scores, students feel they understand the material at a higher level than they actually do? These students may be developing a false sense of confidence after earning high homework scores, only to be defeated on exam day. These are the kinds of observations that are routinely made by instructors teaching courses that contain a web-based homework component.

Our study seeks to add to the body of research examining the effectiveness of web-based homework systems by examining the performance of students taking Finite Mathematics at a medium-sized private university in the Midwest. One group of 24 students was assigned homework using a web-based homework system (WebAssign); the other group of 24 students completed and turned in tradition

pencil and paper homework which was graded by the instructor. Both groups were assigned the same set of problems, simply in different formats. Both sections were taught by the same instructor and in the same format; common exams were given to both sections. This study will investigate the effectiveness of the online homework system by comparing the individual final exam items and overall exam performance of the students in the web-based and traditional homework sections. This analysis will be completed in order to better understand whether web-based homework is equivalent to (or better than) traditional homework for facilitating learning overall. Additionally, the researchers will examine and compare the types of questions that traditional and web-based homework students tend to get correct (or incorrect) in order to gain insight into the depth of learning that may be promoted using either homework system. Student perceptions of how the class structure, materials, and assigned work impact their learning and classroom experience will also be analyzed and compared in an attempt to gain greater insight into the learning preferences of the contemporary undergraduate student in entry-level mathematics courses. This study is preliminary and data is currently being analyzed; statistical results and relevant recommendations for practice and further study will be forthcoming.

Questions for audience consideration:

1. From the professor's perspective, what are the biggest benefits and drawbacks to web-based homework systems and traditional homework formats?
2. From the student's perspective, what are the biggest benefits and drawbacks to web-based homework systems and traditional homework formats?
3. What are the benefits and drawbacks of each system in facilitating breadth of learning?
4. What are the benefits and drawbacks of each system in facilitating depth of learning?
5. Do web-based systems promote the kind of engagement that leads to long-term learning or just short-term competency, and how could we capture this information?
6. Can we identify categories of questions that are better served by using web-based systems, traditional systems?
7. How would we go about this categorization?

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