Online calculus homework: The student experience

Andrew Krause
Michigan State University

The MAA advertises that the online homework system WeBWorK is used successfully at over 700 colleges and universities, and the institution selected for my study has implemented WeBWorK universally across all calculus courses. I used a mixed method approach to examine how students experience online calculus homework in order to provide insights as to how online homework might be improved. In particular, I examined the behaviors, perceptions, and resources associated with online homework. A survey was administered to all students in the mainstream calculus course that provides quantitative information about general trends and informs further questioning. For example, more than half of students reported that they never study calculus with classmates nor in office hours. In tandem with the large survey, I also closely studied the online homework experience of 4 students through screen recordings and interviews.

*Key words***:** Online Homework, Calculus, Study Habits, Student Perceptions, Resources

In the following report, I will describe the importance of understanding how students perceive and experience online calculus homework, based on the fact that calculus is a gateway course for students seeking careers in STEM fields. Then, I will make an argument for the importance of understanding how online homework interacts with students' experiences and perceptions, noting that the literature is sparse in this regard. Finally, I will describe my investigation of students' experience doing online calculus homework. My research describes students' perceptions about online homework and how it interacts with their learning, portrays students' study habits, and identifies resources that are commonly utilized by students while working on online homework.

My motivation for studying this topic arises from witnessing struggles that highly motivated students have in succeeding in their calculus classes. Both as an instructor and as a tutor, I have watched as highly motivated students have spent hours trying to learn calculus by completing their online homework, only to be rewarded with failure on uniform midterm and final exams. It is likely that a large component of learning calculus is tied to doing homework, as is the case for other content areas (Cooper, Robinson, & Patall, 2006), so understanding the mechanisms that relate learning and homework is crucial to understanding how students learn calculus. The literature is fairly sparse in this regard, however, and this study is an effort towards filling some of the gaps. In particular, this study included a qualitative component that attempted to capture data about the student experience, as opposed to student outcomes, because inquiries focused on student outcomes constitute the majority of the research in this area. My purpose is to contribute to an understanding about how doing online calculus homework and learning calculus are connected in order to equip instructors and those who support instructors with knowledge that can be used to improve teaching practices.

Background of the Problem

An enduring challenge of educators across the Unites States is addressing the problem of persistence of students working toward a degree in the science, technology, engineering, and

mathematics (STEM) fields. The educational system has struggled to produce graduates in STEM fields, in part, because students who enter postsecondary education intending to pursue an education and career in the STEM fields commonly move away from those career paths during their undergraduate education. It is estimated that between 40 and 60 percent of students who enter postsecondary education with the intention of pursuing a degree in a STEM field will switch their study to a non-STEM field (Bressoud et al., 2014).

It is often assumed that students drop out of degree-granting programs in STEM fields because they are either unable to afford the expense of higher education or because they are unable to succeed academically in the programs that feed STEM fields. To the contrary, poor instruction in mathematics and science courses, especially calculus, is often cited as a primary reason for students' discontinued STEM course taking (Seymour, 2006). Although poor instruction is related to poor academic performance, students who are academically successful still sometimes leave STEM fields because of negative reactions to the instruction and pedagogical styles that they experience in mathematics and science courses. In fact, it has been determined that students—particularly students who have done well in Calculus I—enter Calculus I with the intention of taking Calculus II, but finish their first-semester calculus class with a change of heart. In a study (Ellis, Kelton, & Rasmussen, 2014) that was part of the MAA's Characteristics of Successful Programs in College Calculus (i. e. Bressoud, 2011, 2013), it was reported 15% of students who started the term with the intention of taking Calculus II changed their mind by the end of the term. While it is a possibility that the taking of Calculus I correlates with other course-taking patterns that may play a role in this this behavior, the effect of Calculus I on students' intentions should be more fully understood as we work to solve the issue of student persistence.

Calculus as a Gatekeeper

Of the 69% of students enrolled in Calculus I that expect to continue and take Calculus II, 58% of students are required to do so based on their intended major (Bressoud, 2011). At the university selected for the study, both Calculus I and Calculus II are required to have been completed prior to admission into the College of Engineering. The only other courses that are also required are a first-semester chemistry course, a first-semester physics course, and a first-semester engineering course. Even among the courses from the other three disciplines, Calculus I is an especially important course because it is a both a requirement in itself and is a prerequisite for both Calculus II and the required physics class.

Online Homework

The literature reviewed for this research suggests that the implementation of online homework is unlikely to damage student outcomes (exam scores and course grades), but there is not strong evidence that online homework substantially improves student outcomes (Bonham, Beichner, & Deardorff, 2001; Cheng, Thacker, Cardenas, & Crouch, 2004; Cole & Todd, 2003; Hirsch & Weibel, 2003; Richards-Babb, Drelick, Henry, & Robertson-Honecher, 2011). These findings provide some justification for the implementation of online homework, because online homework appears to "cause no harm" in terms of exam scores and course grades, while still offering substantial affordances in other areas, such as freeing up department resources for other support programs, providing immediate feedback and grading, allowing for individualized homework sets, and promoting the acceptability of mistake-making (Bonham et al., 2001; Burger, 2012; Carpenter & Camp, 2008; Demirci, 2007; Epstein, Epstein, & Brosvic, 2001; Kortemeyer, 2014; Richards-Babb et al., 2011; Zerr, 2007). While it is still important to

investigate the effects of online homework in terms of exam scores and grades to further justify its use, the continued propagation of online homework makes it necessary to explore forms of knowledge other than statistical comparisons of student outcomes on traditional measures such as grades and exams. It is important that teaching practices align with the use of online homework and are informed by knowledge about how students experience online homework. For example, my survey data suggests that students are more likely to work alone than in collaborative settings, which may influence how instructors choose to structure class time, perhaps choosing to facilitate more in-class collaboration.

Methods

My research combined a quantitative survey with qualitative observational inquiry to determine general trends in student perceptions, behaviors, and resource uses in tandem with providing a portrayal of the individual student experience with online homework.

Research Questions

1. How do students experience online calculus homework?
    a. What are student perceptions about how online calculus homework supports learning?
    b. What are student behaviors associated with online calculus homework?
    c. What resources do students employ while completing online calculus homework?

Sample

The survey was administered to all students the mainstream calculus course at a large public university and was completed with a 23% response rate. Further analysis will be completed to determine the representativeness of the sample.

Participants for the observational study were solicited from two sections that were deemed typical, based on their being taught by a graduate teaching assistants who had at least one year of teaching experience and had previously participated in a teaching mentoring program. Four participants were selected from a pool of 9 volunteers, with attention given to selecting participants that represented several different stories. All of the participants were freshman with varying backgrounds in terms of experience with AP Calculus, with other calculus classes at the institution, and as repeat students for the mainstream calculus course. Each of the four observational research participants also completed the survey that was administered to the rest of the student population.

The Survey

The survey was designed to gather data about students' demographic information (multiple choice), mathematical backgrounds (multiple choice), perceptions about how online homework supports learning (Likert-type questions), study habits (time estimates), and resource use (frequency estimates).

To analyze the survey data, I have examined the basic distributions of the responses in order to identify general trends in student responses. I have also attempted to uncover relationships between the variables by searching for correlations among survey items. For example, I compared perception of online homework as a useful learning tool to perceptions of the clarity of online homework questions as shown in Figure 1.

Observational Study

For the observational component of my study, I gathered two main forms of data: (a) video recordings of student homework sessions and (b) transcribed, audio-recorded interviews. As a secondary data source, I may draw on notes from informal conversations with the participants, most of which occurred while meeting with students to gather the video files they produced.

The video recordings of homework sessions include two data streams. Screen-recording software (Screencast-O-Matic) was installed on the participants' computers to capture the details of their computer work. The screen-recordings provide details about the exact input that students provide the online homework system, and also captured students online activity outside of the online homework system, such as browsing the internet for support and using online calculators like WolframAlpha. A webcam was used to simultaneously to capture students' real-world activity, but did not capture the same level of detail that was captured by the screen recordings. From the webcam recordings it is possible to identify when students are working with paper-and-pencil during their online homework session, but it is not possible to determine exactly what students are writing from the recordings.

I have thus far developed a coding scheme to analyze basic student behavior elements of the screen-recordings, such as the amount of time spent navigating the online homework interface, working on paper-and-pencil, submitting answers, and working with various learning resources. Deeper layers of analysis can be conducted to identify student strategies following an incorrect submission or student resource usage trends throughout homework sessions, for example. I will seek input from the audience in this regard.

Preliminary Results

Both the survey data and the observational data have proven to be informative through my preliminary analyses. The survey data suggest that students find online homework useful, but believe that written homework, in addition to online homework would help support their learning. Students indicated that several traditional resources (the textbook, the department tutoring center, office hours, and study groups) are largely under-utilized while some newer resources (YouTube, instructional websites, and online calculators) are heavily utilized. The observation and interview data suggests that while students find online homework useful, there are changes in the way that the online homework is administered that may better support student learning, including considering how newer resources may be integrated within the experience.

Survey Results

I found that student responses had responses that were skewed either towards agree/strongly agree or disagree/strongly disagree for questions about the usefulness of online homework, the prospect of adding written homework, the clarity of online homework questions, overall study habits, and resource use. The survey items related to student perceptions of online homework (Table 1) suggest that while students find online homework useful in learning calculus, they may also think that assigning written homework would help them learn calculus more effectively. The results also suggest that the clarity of homework questions may be an issue. The survey items related to study habits (Table 2) suggest that students work primarily alone, and few students substantially utilize classmates, private tutors, the department tutoring center, or office hours. The survey items related to resource use (Table 3) suggest that traditional resources are under-utilized, while some newer resources are heavily utilized. I plan to disaggregate the data to examine response trends and relationships between response items. For example, Figure 1 shows that there appears to be a relationship between the perceived usefulness of online

homework and the perceived clarity of online homework questions. After a cursory analysis, the data appears to be less clear for other response items.

Statement	Agree	Disagree
WebWork is a useful tool for learning calculus.	53.2%	29.8%
Assigning written homework, in addition to WebWork, would help you learn calculus more effectively.	51.3%	25.9%
It is easy to determine what WebWork questions are asking.	31.8%	51.9%

Table 1: Responses to Selected Survey Items Related to Perceptions

Study Activity	0 minutes	0-60 minutes	>60 minutes
Alone	3.9%	22.7%	**73.3%**
With classmates	**52.6%**	25.3%	21.4%
Tutoring Center	**42.2%**	27.2%	30.5%
Office Hours	**75.3%**	22.1%	2.5%

Table 2: Time Spent Studying in Various Ways (per week)

Resource	Never	Rarely	Sometimes	Often	Always
Textbook	**45.5%**	**24%**	20.1%	8.4%	1.9%
Tutoring Center	**47.4%**	**18.2%**	13%	13.6%	7.8%
Office hours	**63.6%**	**22.7%**	8.4%	3.9%	1.3%
YouTube Videos	28.6%	17.5%	**29.2%**	**17.5%**	**7.1%**
Online Calculators	14.3%	9.7%	**27.3%**	**28.6%**	**20.1%**

Table 3:Reported Resource Use While Completing Online Homework

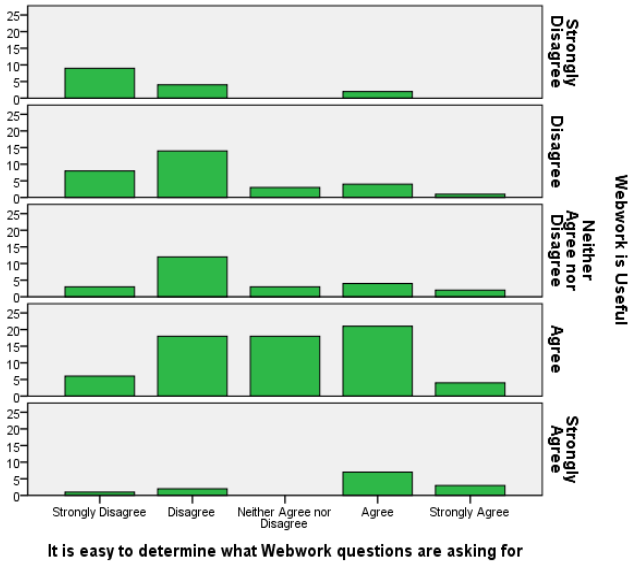

Figure 1:Multi-variate analysis of survey items

Questions for the Audience

1. What are suggestions for making sense of my video and interview data?
2. What other statistical techniques might reveal interesting relationships in the survey data?
3. How can this research be expanded into a more robust research program?

References

Bonham, S., Beichner, R., & Deardorff, D. (2001). Online homework: does it make a difference? *The Physics Teacher, 39*(293), 293–296. http://doi.org/10.1119/1.1375468

Bressoud, D. (2011). The calculus I student. *The MAA Launchings Column of May & December* (May 2011), 4–7.

Bressoud, D. (2013). MAA calculus study: Persistence through calculus. *Launchings*.

Bressoud, D., Mesa, V., Hsu, E., & Rasmussen, C. (2014). Successful calculus programs: Two-year colleges to research universities. In *NCTM Research Presession*.

Burger, E. (2012). Teaching to fail. Retrieved from http://www.insidehighered.com/views/2012/08/21/essay-importance-teaching-failure#ixzz2JY6THQYj

Carpenter, J., & Camp, B. (2008). Using a web-based homework system to improve accountability and mastery in calculus. In *2008 ASEE Annual Conference & Exposition*. Retrieved from http://soa.asee.org/paper/conference/paper-view.cfm?id=9460

Cheng, K. K., Thacker, B. A., Cardenas, R. L., & Crouch, C. (2004). Using an online homework system enhances students' learning of physics concepts in an introductory physics course. *American Journal of Physics*, *72*(11), 1447–1453. http://doi.org/10.1119/1.1768555

Cole, R., & Todd, J. (2003). Effects of web-based multimedia homework with immediate rich feedback on student learning in general chemistry. *Journal of Chemical Education*, *80*(11), 1338–1343. Retrieved from http://pubs.acs.org/doi/abs/10.1021/ed080p1338

Cooper, H., Robinson, J., & Patall, E. (2006). Does homework improve academic achievement? A synthesis of research, 1987–2003. *Review of Educational Research*, *76*(1), 1–62.

Demirci, N. (2007). University students' perceptions of web-based vs. paper-based homework in a general physics course. *Eurasia Journal of Mathematics, Science and Technology Education*, *3*(1), 29–34.

Ellis, J., Kelton, M. L., & Rasmussen, C. (2014). Student perceptions of pedagogy and persistence in calculus. *ZDM - The International Journal on Mathematics Education*, *2*(1), 1–20. http://doi.org/10.1007/s11858-014-0577

Epstein, M. L., Epstein, B. B., & Brosvic, G. M. (2001). Immediate feedback during academic testing. *Psychological Reports*, *88*, 889–94. http://doi.org/10.2466/pr0.2001.88.3.889

Hirsch, L., & Weibel, C. (2003). Statistical evidence that web-based homework helps. *MAA FOCUS*, *23*(2), 14.

Kortemeyer, G. (2014). An Empirical Study of the Effect of Granting Multiple Tries for Online Homework. *arXiv Preprint arXiv:1407.2276*, 1–7.

Richards-Babb, M., Drelick, J., Henry, H., & Robertson-Honecher, J. (2011). Online homework, help or hindrance? What students think and how they perform. *Journal of College Science Teaching*, *40*(4), 81–94.

Seymour, E. (2006). *Testimony offered to the Research Subcommittee of the Committee on Science of the U.S. House of Representatives hearing on Undergraduate Science, Mathematics, and Engineering Education: What's Working*.

Zerr, R. (2007). A quantitative and qualitative analysis of the effectiveness of online homework in first-semester calculus. *Journal of Computers in Mathematics and Science Teaching*, *26*(1), 55–73.