

ONLINE ASSIGNMENTS AND MATHEMATICS LEARNING

by

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A professional paper submitted in
partial fulfillment of the requirements for the degree

of

Master of Science

in

Science Education

MONTANA STATE UNIVERSITY
Bozeman, MT

July 2013

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July 2013

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ABSTRACT

In this investigation, online and written assignments were used to study student learning in an Adult Basic Education mathematics course. Student performance on summative assessments was not significantly affected by the treatments, and a majority of students showed a preference for the written assignments. Students that showed strong familiarity and comfort with online work preferred the online assignments. The Instructor saw great benefits and future avenues for online assignment work.

INTRODUCTION AND BACKGROUND

I chose the topic of online assignments in mathematics for four main reasons. The first has to do with simple demographics. Though I teach at a community college, my students are mostly young enough that they have been online since before they started kindergarten (the current crop of students out of high school were born in 1994 and 1995). It is where they spend most of their leisure time and most of their social time. It was my hope reaching them where they are most comfortable would help them feel more comfortable with math, and help them learn the material better.

The second reason is quite specific to the students that I often teach. The math courses that I have taught are Adult Basic Education (ABE) courses, and are commonly taken by students that have had a less traditional educational path. They are more likely to be older students returning to school, or students that did not achieve good grades in high school math and require upgrades in order to get into their preferred program of study. These students can often show a high degree of math anxiety and some have said to me that doing work online is less stressful for them. They have said that online learning makes them more confident in their work. I have also been greatly influenced by data showing the positive effects of frequent assessment, and with the ease of use of online assignments, I believe that I can help my students learn material better.

The third reason is logistical. Online assignments require almost no time to mark, they can easily be modified from year to year, and can be improved upon with simple editing. I have been posting course material (lecture notes and videos) online for two semesters now, and the students have shown great appreciation of those resources. I have also used online assignments (with written assignments for some topics) in the past for

math and chemistry courses. Some of my colleagues still use entirely written assignments, some use entirely online assignments, and some use a blend of the two.

The last main reason is that online education, in some form or another, is clearly the wave of the future. I personally believe that face to face classroom education will mostly meet its end within my teaching career, and I want to seek every opportunity to see how I can better integrate my instruction with online tools. It's clear to me that educators will only progress more towards online educational resources in the near future, and this increased my desire to investigate what exactly the effects are on student learning and attitudes in mathematics.

My main research question is: "What are the effects of online assignments compared to written homework assignments on student learning in mathematics?" I have prepared three sub-questions to supplement this main question.

- 1) What is the impact of online assignments compared to written assignments on homework completion and quality?
- 2) What is the effect of online assignments compared to written assignments on student attitudes in mathematics?
- 3) What is the effect of online assignments compared to written assignments on the instructor?

My support team consists of four people, two colleagues and two family members. The first colleague is Leslie Molnar who has been an important mentor for me the entire time I have worked at the College of the Rockies, and is someone I have asked for support and advice at every stage during the project. She has been an early adopter at our school of online educational resources, and I have learned a lot from her about these

resources. The other one is Rob Tillman, who is a recent MSSE graduate. Since he has been through this entire process quite recently, he has been a useful asset for information about timelines, and logistical planning.

The two family members on my support team are my brother and sister, Sven and Katrina Heyde. I chose them both for two reasons. They are both excellent writers, and I have valued their thoughts on my capstone report as it has taken shape. Neither of them is directly educated in science or math so I wanted to take advantage of having access to two intelligent and educated people who are not necessarily educated in my field of study. I feel that my writing should always be accessible to people outside science and math, and their input should help me to attain that goal.

CONCEPTUAL FRAMEWORK

One of my concerns when looking at online assignments versus paper assignments was the likelihood of students feeling as though they did not need to do their own work since an online assignment only takes in the answer without looking at any rough work. I was interested to find the results of Beaudrie and Yates (2009), which compared students taking proctored online exams with students taking unsupervised online exams. They found in faculty interviews a graduated level of concern about the validity of grades earned online. Teachers who had never taught online courses “found the idea of online testing completely objectionable and believed that approach should not be used” (p.65). Teachers who taught online courses, but used proctored tests believed that unsupervised tests would produce unreliable results, and teachers who offered unsupervised tests found that the results from these tests were no different.

I believe this is quite an interesting result, as it certainly shows how our ideas are influenced by assuming that we're already doing things the correct way. This is something that partially led to my third sub-question. Beaudrie and Yates (2009) also found that the teachers who believed that there was no difference between proctored exams and unsupervised exams often revealed to having that concern before they started using unsupervised exams, and that concern went away over time as they felt there were no discernible differences in the test scores obtained. This is exactly what Beaudrie and Yates tested, and they compared proctored GPA vs online GPA scores across five different math courses (890 students total). They were able to find that there was no significant difference between the scores using both two sample t-tests and chi-squared analysis.

They did note two limitations. One was that they felt that their sample was quite particular and could not necessarily be expanded to all situations. I mention this since it is something that I am also quite concerned about. Another concern was one that we have often expressed, that summative assessments are not necessarily assessing the math skills of these students and that dependence on online testing only exacerbates that problem. I was also personally concerned that in a study concerned with the comparison in exam performance, Beaudrie and Yates chose to use course grades instead of exam grades. I believe the results of this study do support a primary justification for my AR project, that there is no difference in the grades earned when using primarily online assessment (I think a clear parallel can be drawn between written assessment and proctored online exams).

Interestingly, the work by Beaudrie and Yates in 2009 was considered important enough that Englander, Fask, and Wang (2011) published a paper entirely as a comment on the work of Beaudrie and Yates. Early on in the paper they mention a statistic that shows why I think the study of the improvement of online education is so important, that less than 10% of higher education enrolment was in online education in 2002, and by 2008 that had risen to over 25% (they did not mention whether this included blended formats or face-to-face courses with an online discussion component). Englander et. al. (2011) praise Beaudrie and Yates for their work, while acknowledging a couple of faults. Since all of the classes had sections with both proctored exams and unsupervised exams, if students knew in advance which one they were registering for, weaker students (whom Englander et al. claim are more likely to cheat, citing previous studies) could gravitate towards classes with unsupervised exams. By failing to account for this, Englander et. al. (2011) state that Beaudrie and Yates may have opened the door to significant selection bias.

They also had concerns with the same issue that I had with the study, that course grades are not as good an assessment of the variable of interest as exam grades would have been. Another problem that I did not notice in the original work is that data was used from six years of classes, which is quite a problem given the massive technological advances that occurred in online education between 2002 and 2008. Englander et. al. (2011) concluded that the findings of Beaudrie and Yates (2009) are well intentioned but overstated, and further, more consistent study is needed. I included both papers because I believe they are useful for guidance as to why my area of study is important, techniques to use (making sure to account for possible selection bias, making sure to use

measurements appropriate to your values of interest) and avoid, and the importance of selecting the data to use carefully.

Mayes, Ku, Akarasriworn, Luebeck, and Korkmaz (2011) provided an essential part of my theoretical framework with what was essentially a literature review. I found it so valuable because it touched on many ideas that had been discussed in previous Education, Curriculum, and Instruction (EDCI) courses and issues that I had considered while working on the idea for this project. In particular, they point out that a critical part of assessment is instructor feedback and ongoing assessment. Also in support of much of our discussion, Mayes et. al. (2011) mentioned the usefulness of formative assessments, saying that they motivate practice and improve instructor feedback.

In addition, they discussed placing importance on the idea of “strategies for equitable administration and scoring routines such as detailed, topic specific scoring rubrics for assignments” (Mayes et. al, 2011, p. 159). I hadn't really considered how important it would be to be clearer in my rubrics, thinking this to be something that would be more important in chemistry or biology than in math, where the focus can often sit primarily on obtaining the right answer.

I drew some ideas for methodology from the work of Angus and Watson (2009). They found repeated exposure to low mark assessment significantly improved performance as measured by a final proctored exam. Interestingly, they found that this effect was seen regardless of the level of performance on the low mark quizzes (this is something I am keen to explore, and part of the source of my first sub-question). I was pleased to read that they structured their quizzes in much the same way that I structure my online assignments, in that they make sure to allow marking for numerical answers to

not be too punitive for slight entry errors (some are so restrictive that rounding too early can lead to an incorrect answer).

The most useful part of Angus and Watson (2009) is that they correct for several important factors in their results. Firstly, they used data from a peer tutoring service (called Peer Assisted Support Scheme, or PASS) to measure student effort during the semester. This is especially good for their study as they were attempting only to correlate student effort on the formative quizzes with performance on the future summative exams, not student performance on the formative quizzes. This is an important result, as it shows that the importance of frequent assessment is clearly shown when the assessments used are provided online.

Secondly they corrected for in-course mastery by including the midterm score as a variable. This is the only item that I somewhat disagree with, as they are using a mark that is obtained from halfway through the treatment to see if the treatment is working. They do, however, smartly include a variable to represent the level of previous mathematics experience, differentiating the students into three groups in terms of their highest level of previous mathematics achievement. I incorporated the idea of correlating general student effort with student performance in online assignments and summative assessments, as this is indeed the main reason for sub-question one. I used initial survey data to assess previous mathematics abilities and experiences.

Another study that I looked at for techniques was done by Macedo-Rouet, Ney, Charles, and Lallich-Boidin in 2009, and focused on math lessons delivered to 122 undergraduate biology students. Like in the Angus and Watson (2009) study, they attempted to correct for incoming ability, though in this case they used a survey with

questions about previous math experience, quality of previous math performance, and how recent the math experience was. They also asked a series of questions that I did not bother with and were probably not that necessary in 2008, assessing students on their web experience, and frequency of use. For example, in the math 080 course I taught in the winter of 2012, I had many questions about my online assignments, but not one of the students betrayed any lack of familiarity with working online. The main reason that I found this study useful, though somewhat dated, is that it focused on the usability of the website, making it convenient and logical in setup and use. It's clear that a major benefit of online learning for students is the convenience, therefore good website design is critical to making sure the students feel that the course website is easy and intuitive to use.

Overall, review of selected literature and research eased my mind about my concerns regarding my project plans. Reviewing this literature provided me with the guidance I needed and helped confirm some of my previously held ideas. I was concerned about students not feeling the need to do their own work, and Beaudrie and Yates (2009) helped alleviate that concern. I was also encouraged that their study showed the validity of online testing. Englander et. al. (2011) helped me to see some of the possible faults with Beaudrie and Yates (2009) that I might not have seen for myself, and helped to refine my methodology. Mayes et. al. (2011) supported my ideas about the importance of formative assessments, and Angus and Watson (2009) guided both my methodology and my data collection.

METHODOLOGY

For my treatment, I used a class of Math 090 students at College of the Rockies in Cranbrook (COTR), Canada. This is a course offered in the Adult Basic Education (ABE) department and is the equivalent of grade 12 mathematics. The class ran from January 7th, 2013 to April 19th, 2013 which was a 15 week semester with a one week reading break. The class initially started with 25 students, and one added later on. Seven students officially dropped the course at various times during the semester, so I was dealing with a data set of 19 students. The class met for four 90 minute lectures per week (this is standard for ABE math classes) from Monday to Thursday each week. Students usually take this course for a variety of purposes, as it is a requirement for future math courses that are required of education and business students and a prerequisite for anyone seeking to pursue calculus. I divided their semester in half, and they received traditional written assignments from their instructor for the first half and online assignments from me for the second half of the semester. In the first week of the semester, before the preliminary surveys were taken, they were asked to sign an informed consent form if they wanted to participate, and the four students that chose not to participate were all in the set of students that ended up dropping the class. It was made abundantly clear to them that there was no specific benefit to participating and no punishment if they chose not to participate.

The class was taught by Debra Heal, a 20 year instructor in the ABE department at COTR. She normally teaches math and physics (at both the ABE level and the undergraduate level), but has taught chemistry and biology in the past. She has only recently started using online resources as any part of her courses, initially only posting

notes online, and recently progressing to posting video recordings of lectures. She normally uses an assignment structure based around having a written assignment at the end of each small topic (approximately 22 written assignments over the course of the semester).

For the first seven weeks of the semester, the students did their regular written assignments when they finished the appropriate topics. That turned out to be 13 written assignments. For the second half of the semester, they would receive the written sheets from Debra, and I wrote an online assignment on Moodle based on that sheet. My online assignments essentially used all the same questions as the written assignments that Debra would have used in any other year. Sometimes I would use the questions exactly as they were written by Debra, and sometimes I would break down longer questions into parts. For example, for a question where the students were asked to graph $y=3*\cos\{x + (\pi/4)\} + 4$, I broke it up into two questions. In the first one, I asked them to complete a matching question identifying the phase shift, amplitude, vertical displacement, and period, as shown below in Figure 1. Then in a second question, I gave them a multiple choice question where I asked them to identify which curve was the correct one.

Question 4
Not yet answered
Marked out of 3.00
Flag question
Edit question

Match the important characteristics of the equation $y = 3 \cos(x + \pi/4) + 4$ that are listed below

amplitude	Choose...
period	Choose...
vertical displacement	Choose...
phase shift (horizontal displacement)	Choose...

-4
 The period is π
 3
 -3
 3 units up
 4 units up
 4
 3 units down
 The period is 2π
 $\pi/4$ to the right
 $\pi/4$ to the left
 4 units down

Figure 1: Sample question from online assignment.

I used a variety of question types when writing the online assignments, including multiple choice questions, matching questions, numerical answers, and in one case, essay type questions. All students were given two attempts at each online assignment, as it was discussed that the purpose of the assignments is to allow any student that does the work to get close to 100%. For the written assignments, Debra does not take corrections, but will help students with the work, and check the assignment over before it is handed in for any students that ask. After the students would submit their answers for the first attempt, they would receive their grade on each question, and when possible, detailed feedback on questions, pointing students towards the error that likely caused them to choose one of the distracters instead of the correct answer. One of the great things about Moodle is that this is also possible in a numerical answer type question. If the correct answer is 500, but a very common algebra mistake could lead to an answer of 1000, then I can put 1000 in when writing the question, declare that a student will get no marks for it, but I can add feedback pointing them to their error if they enter that value or an answer near that value. It is possible to allow for rounding errors in Moodle, which is critical when dealing with any calculation question.

I collected a variety of data on this treatment, as I was interested in student performance on the homework assignments and summative tests and student attitudes about the assignments, mathematics, and online resources in general. First, I collected quantitative data from the written and online assignments, recording completion rate and the quality of work achieved. I also collected quantitative data from the summative tests given by Debra throughout the course. There were four unit tests: two of which fell in the non-treatment phase and two in the treatment phase. For qualitative data, I had the entire group of students who chose to participate complete surveys in the first week (January 7th-11th, 2013), the eighth week (after the last written assignment, March 4th-8th, 2013), and the last week of school (April 15th-19th, 2013). I also conducted follow-up interviews with a sample of these students in the first and last weeks of the semester.

I tried to ensure reliability and validity in my data collection tools by relying on my readings and experience. I triangulated my data for my main research question and my first sub-question by collecting two types of qualitative data (student surveys and interviews) and quantitative data from assignment and summative test grades. The surveys that I used were adapted from a very similar survey that I used in an assignment in a previous MSSE course, with changes made based on that results and feedback from that assignment. I also took guidance from my literature review in terms of the background information that I requested in the surveys. I structured the interview questions with guidance from an interview assignment in a previous MSSE course. Additionally, for the online assignments I gave the students, I used the assignments that Debra normally assigns and modified them only slightly. I did because I believed that assignments that she had been using and updating for years would be much better than any I

could write from scratch for the purpose of the study. Also, I wanted to remove additional variables to help prevent confounding.

Copies of the surveys are included in Appendices A, B, and C. I chose my sample for interviews by randomly ordering the surveys that were returned to me and selecting every fourth survey for an interview. If the student that completed the selected survey did not answer yes to the “I consent to a follow-up interview question”, then I simply selected the next survey in the pile. I also had to do this when students did not respond to e-mails regarding setting up an interview meeting time. The interviews were recorded and transcribed, and then the transcript was e-mailed to the students in question so they could check it for accuracy (member checking). A data collection matrix has been included below, linking each research question and sub question to my collection instruments. The research methodology for this project received an exemption by Montana State University's Institutional Review Board and compliance for working with human subjects was maintained (A copy of the application is included in Appendix D)

Table 1:
Data Collection Matrix

Data Collection Matrix	<u>Data Sources</u>			
<u>Research Questions</u>	Student Surveys administered before, during, and after the course	Student interviews administered before and after the course	Analysis of homework and summative test work	Teacher interview administered after the course
What are the effects of online assignments compared to written homework assignments on student learning in mathematics?	X	X	X	
What is the impact of online assignments compared to written assignments on homework completion and quality?	X	X	X	
What is the effect of online assignments compared to written assignments on student attitudes in mathematics?	X	X		
What is the effect of online assignments compared to written assignments on the instructor?				X

In summary, I gave a class of ABE mathematics students 13 written assignments over seven weeks and nine online assignments over the following seven weeks. I analyzed their attitudes and opinions via surveys given in week one, week eight, and week fourteen, with follow-up interviews conducted after the first and third set of surveys. I also analyzed their progress quantitatively by looking at their assignment and

summative grades and looked at the effect on the instructor with a post-treatment interview.

DATA AND ANALYSIS

My total sample was 19 students. 26 students started the semester and seven dropped the class, either officially or they simply stopped showing up entirely. I have excluded two students from the data set for reasons that are discussed below so I was dealing with $N=17$. There were ten female students and seven male students in the sample. The average age was 23, though this is a somewhat unclear representation of the classroom as there were more mature students with ages of 28, 30, 35, and 41 years. The remainder of the classroom were 21 and under. This is a common demographic breakdown for an ABE classroom, mostly younger students, with a few mature ones returning to the classroom. Survey data showed that all four of the mature students were in their first year or first semester back in the classroom, all after extended absences. As I mentioned in the methodology, I looked at 13 assignments in the non-treatment phase, and nine assignments in the treatment phase. Student surveys were given in the first week of the semester (first week of the non-treatment phase), the eighth week of the semester (first week of the treatment phase) and the last week of the semester. Follow-up interviews were conducted after the first set of surveys, and the last set.

The first part of the data to look at is to try and answer how the online assignments impacted student performance. First, we can look at their performance on the actual assignments, where the non-treatment mean was 87.1%, and the treatment mean was 78.5% ($N=19$).

At first glance, it appears that the online assignments clearly harmed the students' grades, but a closer look at the data reveals that two of the students quit doing work almost entirely around the time when the online assignments started up in the middle of the semester. One of these students, Student 13, did two of the nine online assignments. Student 11 did only one of the nine assignments. Both of their test grades were very poor, and Student 11 actually didn't show up for the last summative test or the final exam. I say this not with the intent of shaming them, but to show why I think it is reasonable to exclude their data, and why I will do so for the remainder of the data analysis. If those two students are removed from the data set, making $N=17$, the non-treatment average becomes 87%, and the treatment average becomes 86.2%. These numbers are clearly very similar, and a t-test confirms this, we fail to reject the H_0 that $\mu_1=\mu_2$ ($\alpha=0.05$). So, overall, the online assignments did not appear to help or hurt overall student performance on the assignments themselves. Since I chose the treatment, I had of course personally hoped that the online assignments would show grade improvement, but the assignment grades were quite high generally (the third quartile of students received grades of 100% in the non-treatment and treatment phases).

On an individual level, seven of the 17 students showed a change of more than five percent in the non-treatment and treatment assignment grades. Of these students, three of them showed an increase in average grade in the treatment portion and four showed a decrease. These assignment score increases appear to correlate with increases in summative test scores, as two students (Student #5 and Student #9, both B students) also showed a significant summative test score increase, and the third showed a small decrease. Of the four students that did significantly worse on their online assignments,

the trends are significantly less clear, as only one of them showed a significant decrease in test scores (Student #7, a C student), one of them showed an insignificant decrease in test scores (Student #8, an A student), and the other two students (Student #3, who barely passed, and Student #14, a high B student) actually improved their test score mark while going through a decrease in their assignment grades. All in all, no conclusive correlations existed between the assignment score and the summative test score, though it is worth noting that while there wasn't an overall change in the student average, there were some significant changes on the individual level.

I also had a personal theory that online assignments would cause more students to do a portion of the assigned work, instead of simply not handing in a written assignment out of embarrassment of only understanding half the material. This theory is not particularly borne out in the data; however, as the percentage of homework assignments with zero values yields exactly the same value for the non-treatment and treatment phases, 5.88%. This number could theoretically be slightly skewed against the treatment phase, as the instructor has a rule of not counting the student's four worst assignments of the semester, but that is also not particularly borne out by the data, as no significant spike in uncompleted homework appears right at the end of the semester.

I believe that the most likely reason for the lack of difference between the homework grades in the treatment and non-treatment phases is that I wrote online assignments that were similar in content to the written assignments that were used for the non-treatment phase. I did this for two main reasons. The first was a desire for simplicity. I desired to design my treatment to minimize possible sources of confounding as much as possible. I didn't want to affect the incoming data by changing the way that

students were being assessed too drastically in the middle of the semester. The second was because I was doing the treatment in a classroom that was not mine, and I wanted to keep the assignments as similar as possible to increase the comfort of the instructor, who was doing me a large favor by opening her classroom to me.

However, there was overall quantitative data to inspect beyond the homework grades. Two summative tests were administered during the non-treatment phase and two were administered during the treatment phase. This data can be seen in Table 2.

Table 2:
Summative Test Results (N=17)

	Test #1 (non-treatment)	Test #2 (non-treatment)	Test #3 (treatment)	Test #4 (treatment)
Mean	80.2%	66.5%	72.2%	69.8%
Standard Deviation	14.5%	18.1%	14.5%	15.0%

These numbers are with the two aforementioned students removed from the sample. These values do not show a significant difference between the treatment (average = 71.0%) and non-treatment (average=73.4%) phases, particularly given the large standard deviations, though the non-treatment phase is slightly higher. One likely reason for this small difference is that the first test has historically been the least difficult, since it deals with mostly review material, as confirmed by the instructor. I would say the data shows no significant difference for the class overall in terms of test scores between the two phases.

If we look at portions of the class, these results continue to hold up. If the class is divided into three groups by final class mark (top four students (anyone that got an A- or better), middle six students (anyone that got from a B- to a B+), and the bottom seven students (anyone with a C+ or lower)), only the bottom group shows a significant change

in test marks between the treatment phases. Comparing the non-treatment phase to the treatment phase, the top group showed an insignificant decrease of 0.125%, the middle group shows an increase of approximately 2% (insignificant given the sample size), and the bottom group shows a significant drop, from 64.7% to 57.3%.

There are several ways to interpret this situation. First, given the size of the sample, any quantitative interpretation must be taken with a grain of salt. Second, the highest scoring student in the bottom bracket, Student #15 who they missed a B- by 1%, skewed the data somewhat with an excellent mark of 90% on the first test. Though, removing that student from the sample only changes the difference in the phases to a 5.9% decrease (from 7.4%), hardly a massive difference. Third, it is clearly possible that students in the lowest achievement bracket are adversely affected by the online assignments. This would be quite a distressing outcome, as I had hoped that the lower achieving students would see more benefit from the reduced stress of an online assignment that can be submitted at home. They do show a slightly greater drop in their assignment grades from 86.5% non-treatment to 83.1% treatment, though not in a statistically significant way. Another possible conclusion is that the later material is more challenging than the earlier material (the entire trigonometry unit was during the treatment phase) and that the lower achieving students were more affected by the more difficult material. This is something I would like to examine, perhaps by using historical data from Math 090 and correlating overall performance to performance on specific exams.

I believe it is actually most likely a combination of these students not performing as well with the online material, struggling with the more challenging material, and

somewhat skewing the data through not working as hard later in the semester (two of the seven students in this group admitted as much to me). There does not, however, appear to be an overall effect from not completing assignments because the total number of uncompleted assignments was so low that there was not much data to analyze.

On an individual level, if we define significant change as a greater than 5% difference, then four students saw a significant increase. Though this is quite a small set, I do think it is interesting because in their survey data all four of them stated strong comfort with online education, and three of them stated a significant preference for the online assignments. They were, in fact, the only students to do so, which I will go into in greater detail in discussions of qualitative data. Basically, those students who stated strong comfort with online work and tended to prefer it performed better on summative tests in the treatment portion of the semester.

I should acknowledge that there were five students that saw a significant decrease in their summative test performance. I don't think this is as significant a number because one of those five told me repeatedly of their hatred for trigonometry. This student stated that "trigonometry in wave form and I are quite antagonistic towards each other". Two of the others openly admitted to not working as hard in the second half of the semester.

As important to me as performance was, student attitude towards online assignment work, online education in general, and whether those factors could be seen to affect other student attitudes towards mathematics was equally as important. The first thing to discuss is that the clearest result from all of my data is that students significantly preferred the written assignments to the online. In my post-treatment survey, I asked students to rate on a 1-5 Likert scale their agreement with the following statements "I

prefer the online assignments to the written assignments" and "I prefer the written assignments to the online assignments". I did put both of those statements in there to help with the usefulness of the numbers that I obtained. The results were mirror images of each other, as shown in Table 3.

Table 3:
Survey Results #1 - Assignment Type Preferences (N=17)

	Strongly Agree (1)	Somewhat Agree (2)	Neutral (3)	Somewhat Disagree (4)	Strongly Disagree (5)	No Opinion (6)
I prefer the online assignments to the written assignments	0	3	2	4	8	0
I prefer the written assignments to the online assignments	8	4	2	3	0	0

This is an extremely clear statement by the class as a group (In the future, I will use this scale and refer to average values). Their clear preference to the written assignments was backed up by comments in the surveys. A common complaint was about the lack of available partial credit for questions in the online assignments, as evidenced in comments like "can't get part marks for online assignments" and "either right or wrong, no part marks". Several students also stated that "it took extra time just to enter the work when you did the work anyways." Students also identified that one assignment in particular was quite an intensive use of time (some of them used the word "waste") which is a fair criticism. The assignment in question was on proving trigonometric identities, and after much discussion, neither Debra nor I could see a way

to set up this assignment online other than having the students enter all of their steps in an essay type question format. This somewhat defeated the purpose of doing it online, but I wanted to stay true to my planned methodology, and I think it was useful in showing the limitations of online assignments, at least at this time.

I do feel that there are several aspects of this treatment I could have done differently to prevent the low opinion of the online assignments. Debra noted to me in our interview "I was worried about whether going online was going to affect some of the students because I had been hearing lots of trepidation from the students in terms of themselves having to do stuff online", and I absolutely could have and should have done a twenty minute demonstration with the class. The only reason I didn't do this was that I've never done it with any of my own classes that I have used online assignments in, and never had any significant trouble with it. This was clearly a huge oversight on my part, and something I should have corrected. Also, if I had a larger class with a sample size close to 50, I definitely would have liked to split them into two groups, with the second group doing the online assignment portion first, then the written. This wouldn't perfectly solve the problem, since two groups of students can't always be perfectly compared, but it would give the chance to look at whether a major issue was that I was changing something that they'd grown comfortable with.

Lastly, I would want to write the online assignments so that the differences from the written ones that Debra was handing out were much greater. I would do things like changing up the question styles, break down longer questions into a step by step format (I did this in some questions, but it could have been done a lot more), ask questions in different ways that are more conducive on an online format. Most importantly, I would

use the format more to tie together examples with detailed solutions with similar assignment questions. I would start by showing the student the entire process of solving, for example, a question like "find the general solution of $2\cos(2x) + 1 = 0$ ". This question has several different steps, from finding the reference angle, to finding all appropriate solutions between 0 and 2π , to condensing those solutions down to the appropriate period, to deciding which solutions need to be used in the final answer, and finally to writing the general solution. Then I would give them a similar question (or more than one) and have them do each of the individual steps as separate questions. Finally I would have them work from a similar type of question all the way through to an answer with the student directing every step. In this way I feel I could make the assignments more like a tutorial experience, something that I believe they should be at this math level.

The lack of difference was evident in the survey responses as some of the students felt like the online portion was just extra work, as opposed to an entirely different approach. I got more than one comment like "It increases the amount of time spent on the assignments without increasing the comprehension of the material." This type of comment came up in survey comments several times, though not in interviews, even when the same student wrote it in the comments. I feel that this discrepancy is mostly because these students simply did not feel comfortable stating these criticisms to me in person.

It is worth mentioning several potential conflicts of interest with my sample group. I chose to do my research in a class that I was not instructing to attempt to decrease these kinds of issues, but my school is a small community college in a small

community that I've lived in for 20 of the last 25 years. As such, I had many interactions with members of my sample group outside of their Math 090 classroom. Six of the students were enrolled in a Chemistry that I was teaching concurrently, and Student #18 was a former student. Additionally, Student #6 was a former private tutoring client of mine, Student #4 played on my recreational soccer team last year, and Student #15 used to work at my family's small business. I believe that one of the perks of a small school in a small town is that since everyone does know everyone, these points of contact matter less than they might in a larger centre. In this particular class, I had outside experience of some form or another with ten of the 17 students in my data set. But for people from a town this small, this is such a fact of life that I believe it did not greatly affect my results one way or the other. One potential area of effect was clearly seen in the interviews, in that students did not seem to feel comfortable being overly critical of the online assignments when speaking with me in person, even when the same student felt comfortable writing those criticisms down in surveys. In a future study, I may attempt to have the interviews done by a third party, with assurances given to the student that I will only read the transcript, in the hope that they will be more comfortable offering criticism.

I also wanted to investigate if student attitudes towards online learning resources in general as well as whether or not attitudes towards mathematics could be affected by the use of online assignments. To that end, I asked several questions on all three surveys to attempt track student opinions longitudinally. These were all done on a 1-5 Likert Scale (ranging from strongly agree to strongly disagree), and results are shown in table 4 below

Table 4 :
Survey Results #2 - Student Attitudes (N=17)

	Initial Survey	End of Non-treatment	End of Treatment
I feel confident in my ability to use online resources	2.2	1.9	2.1
I enjoy online education on online education resources	3.5	3.2	3.2
I feel confident in my mathematical abilities	2.2	2.3	2.4
I believe that if I put effort into my math work, I will achieve good grades	1.3	1.5	1.9
I feel like my grade in math is directly within my control	1.9	1.9	1.9

These five were my main questions about attitudes towards math and online education, and I feel the data quite clearly shows that the semester did not really affect any of them. This is both good and bad news. Obviously I had hoped that the exposure to online education would improve opinions towards it, but it also appears that even though students rather uniformly preferred the written assignments, it did not change their opinion of online resources in general. I believe this reinforces my idea from earlier that the main problem with the online assignments (in the eyes of the students) was the execution. If I had written them differently and/or reverse the treatment order, I believe I could have had different opinions about the treatment, and I think that the consistent attitudes towards online education and consistent confidence in their online abilities support that.

Lastly, I interviewed the instructor when the semester was over. Her first clear sense of benefit was in the lowered amount of time dedicated to marking, "ok, there is a way for me to cut the marking load down by doing it here", but she did have several concerns about doing the assignments online. Her first initial concern was identical to mine, she was worried about losing students to their trepidation to doing online work. She was concerned "about the fact that it wasn't me doing them, so I didn't have that control over what it was going to look like", and she was worried about losing touch with the students, not being able to track what they were doing, where they were struggling. She felt that the first concern did not really pan out, the students came back to her and said "you know, that wasn't that bad", and she felt that any students that truly lost track of the class during the second half of the semester (of which there were clearly two, as discussed above) did not do so because of issues with online work.

The second issue was mostly resolved through good lines of communication between her and I, though she did feel "that you didn't always get them in as quickly as I would have liked to see them, so that part was difficult for me because I did feel a lack of control as things went on." This was definitely an effect of doing an action research project while also working full time, I didn't always put up the online assignments as quickly as I would have liked. So it was completely a fair criticism, but we did work through any timing issues with good communication. This, I believe, is actually one of the good benefits of online assignments for the instructor, as it is extremely easy to adjust due dates and extend when necessary without worrying about getting a bunch of work from students at different times.

The last issue was not so easily resolved, as her feeling of being disconnected from the students appears to partly be a fundamental issue with online assessment. Deb said that "I did feel like I did lose some contact with what the group was doing, as a whole and that was because, I think that was Moodle." She was expressing this as a frustration with identifying individual questions where students were struggling when looking at results of an online assignment on Moodle (the online system used at College of the Rockies). She also felt that since she wasn't seeing the students' raw work, she felt like she didn't know where they were making their mistakes.

One solution that Debra posed was that she would take a half and half approach, still using her old assignments, but converting parts of them over to online when feasible. By then still having the students complete a written document, she can mark only the parts of the written document that she needs to (thus significantly cutting down on marking time), and have the written work there as a back-up. I believe that this would partly solve the problem of feeling disconnected from the students, though I think it would somewhat delete the convenience advantage for the students themselves. For this reason I would hope that this would not be a long term approach, but a bridge as she becomes more comfortable with the technology. Also, online education technology is ever changing, and there are many online resources already available that may offer a solution that I am simply not aware of yet.

I believe part of her issue can be overcome with better use of Moodle also. There are some formatting issues with viewing grade breakdowns of submitted student quizzes (the format we use for assignments in Moodle leads to them being called quizzes by Moodle), but I believe these could be solved with careful setup of the program. While it

does have limitations, it's quite customizable in many ways that I have yet to explore. Additionally, as discussed before, the more that questions are broken down, the more word problems can be input into Moodle.

This is where Debra saw a real opportunity, because she and I agree that the biggest problem with students at this level and word problems is that they cannot translate the text into a diagram or equations. As she said, "If they can get the diagram, they can do the rest of the question." This is where online assignments can excel, since it is easy to generate drawings of multiple similar questions and have students practice the first step repeatedly before getting into the entire process. Another possibility is to guide them through the process step by step in the first question, then write a question where they have to choose the steps and the order from a list, then include a third question where they have to do all the steps themselves and just give the answer. This is something that I did somewhat consider before starting the project, but I did not want to radically alter the assignments when doing the online portion out of fear of getting data that couldn't be easily compared. Given the students' impressions of the assignments as well as Debra's observations, this will definitely guide how I approach online math assignments in the future. We both believe that this will be a good way of helping students to learn mathematical reasoning. This was the last point that Debra made in the interview, and it definitely made me think that I'd converted her.

"With the first one, break down the steps, and have them do them. With the next one, "what's your first step?", "what's your second step?", and so on. And guide it, you don't even have to mark it. It could be not for marks, it could just be a leading process and then have one for marks. I'm looking at this assignment

and thinking there's huge potential between the two. I'm not sold that it's completely going to cover everything, but I can sure see how it's going to cover stuff that I can't do otherwise, if I don't go that route." (Debra Heal, May 2nd, 2013)

The assignment she was referring to there was actually a physics assignment, so I believe she's considering porting these ideas over to her other classes.

Overall, my data showed no significant quantitative change in assignment performance or summative performance when using online assignments. Students expressed a clear preference for written assignments in surveys, for a variety of reasons. The instructor felt that there was clear benefit in using the online assignments, and intends to use them more in the future.

INTERPRETATION AND CONCLUSION

Overall, I believe my data shows that the overall effects of online assignments are beneficial to the mathematics classroom. My data does clearly show that there is no difference in student performance on homework or on summative tests (see Table 2). Even though the students clearly preferred the written assignments (see Table 3), I believe they can be brought around with more experience, and by improving the quality of the online assignments. I believe the most significant benefit is clearly to the instructor, who can save a lot of marking during the semester, which I believe can translate to better teaching. This time could be spent on other tasks that improve the

courses such as writing and administering more formative assessments that could also be administered online.

The effects of online assignments on homework completion and quality appear to be none, shown by the statistically insignificant difference in average homework marks in the non-treatment and treatment phases. The effects on student attitudes appear to be minimal, as even though they stated a clear preference for the written assignments, the online assignments didn't change their confidence in their ability to use online educational tools. Online assignments also did not change their opinion of online education as a whole or their opinion of their mathematical abilities. The effect of online assignments on the instructor was clear, as the instructor in this case had never used any type of online assignments before this, and is now considering integrating them through not only her math classes, but also her physics classes. I have profusely thanked her for allowing me to use her class for my project, and it is good to see that she felt there was some benefit to her future teaching.

The study affected me personally in several important ways. First, the information I gained from the students' surveys and interviews will help me craft better online assignments in the future. I had gone into the process looking for clear quantitative data showing me that online assignments were better, and found that the true picture was much more complex than that, which also told me a lot about the nature of classroom research. Also, I learned a lot from the process of collaborating with Debra. Simply observing another instructor explaining math concepts has affected the way I will teach those concepts and similar ones in the future.

This project has also increased my desire to go further with the use of technology in assignments. When constructing these assignments, I stayed mostly within the boundaries of what I already knew in Moodle. The questions were constructed as close to the ones in the written assignments as was feasible. I sometimes broke down larger questions into multiple steps, something I will be doing a lot more of in the future. For example, Moodle didn't have a built-in tool for graphing, so when dealing with trigonometric graphing questions, I chose to have students identify important values in the function and then identify the correct graph from a group of graphs generated on the online tool fooplot. In the future, I would like to have them draw their own graphs, but I need an appropriate mathematical tool. I also had them enter in their entire trigonometric identities proofs, line by line. This was quite cumbersome, as they mentioned to me several times. I hope to find an online tool that would allow them to show cancellation and substitution to make that a much smoother process.

I believe my study clearly shows that online assignments can be brought into the math classroom without any fears of deleterious effects on your students. However, my results also show (in particular in student attitudes towards the online assignments) that if the work is not that different from what they were doing in the written assignments, students feel like it is just extra work. I believe that using the technology to guide students through problems by offering longer problems in multiple ways and by feeding students parts of the work of more complex questions will allow the true benefit of online assignments to reach the student. In particular in math, this can be used to help teach students reasoning skills (as discussed in the interview with Debra) in word problems and

this will definitely be how I approach online assignments in the future. This would also be a good direction to take a further action research project.

I think that this would particularly be beneficial to the high school math teacher, who can not only offload some of their marking work, but also bring in a system of handing in assignments that is not tied to someone being in class at a specific time on a specific day. I do grant that I do not have specific data on this, but I have also worked quite a bit as a math tutor, and many of my students have been heavily involved in athletics that require them to miss a great deal of class time. I think this would be an organizational boon to all teachers, though I do not know how applicable my findings would be for younger learners.

Going forward, I have many questions that I would like to answer using what I have learned from this study. I would like to find algebra tools that allow students to move variables around, substitute from other equations (for trigonometric identities, for example), and show simplification and cancelling. I know this can be done using a more complicated tool like Maple or Mathematica, but I was hoping for something more accessible to my students. I believe this software must be out there, I just need to find it and figure out how to integrate it into Moodle. I would also like to figure out how to better integrate graphing tools like fooplots into Moodle to allow better production and manipulation of graphs, which is absolutely required for math 090. Additionally, I would desire to focus on writing future assignments so there are more examples of the initial steps of word problems, so students can focus better on interpretation. As I said above, I believe there is the potential for a follow-up study in teaching younger students intensive word problem interpretation, using online assignments to produce many random versions

of the same problem. I would also like to structure more problems around teaching the students complicated multi-step processes in parts. This is a place where online assignment work can excel, since instant feedback and multiple attempts can allow for a more interactive experience than handing in a written assignment and waiting for it to be marked.

VALUES

This study has impacted my teaching in several ways. I intend to use online assignments in some way or another in all of my classes in the future, so the best results out of this study for me were the aspects of online assignments which my students did not like. Their responses that the assignments must not feel like extra work were useful as they showed me that I have to use the advantages that online assignments provide to make assignments that are distinctly different from the written work. My students mentioned appreciating the specific feedback to wrong answers, and I will definitely use that a lot more in the future. Even though at the beginning I was most interested in the quantitative data, it is the qualitative data that will lead my future work.

I worked with another teacher on the project out of a desire to remove the influence of my teaching on the data that resulted. I learned a lot from this process, in particular in terms of the perspective of someone that really had not done any online assignments before this. It became clear to me that student apprehension about online assignments was a considerable concern, something students did not voice to me in surveys, or interviews, or personally, but felt comfortable voicing to their instructor when I was not in the room. This points me towards a clear goal of making sure that students are more comfortable with the online portion of any course and demonstrating clearly

what will be expected of them in their online work. Debra also brought me more to the idea of using online assignments to teach procedures and thus, better critical thinking skills in math students. I believe this will be the most important take away from my study, as it will allow me to expand my use of online assignments beyond simple homework to something more like a directed, interactive tutorial. I intend to use what I have learned from this experience to alter the way that I use online math assignments to customize them more to the needs of my students and to help my students to become more comfortable with the process early in the semester.

REFERENCES CITED

Englander, F., Fask, A., & Wang, Z. (2011). Comment on “The Impact of Online Assessment on Grades in Community College Distance Education Mathematics Courses” by Ronald W. Yates and Brian Beaudrie. *American Journal of Distance Education*, 25:2, 114-120.

Akarasriworn, C., Korkmaz, O., Ku, H.-Y., Luebeck, J., & Mayes, R. (2011). Themes and strategies for transformative online instruction: a review of literature and practice. *Quarterly Review of Distance Education*, 12(3), 151.

Angus, S.D., & Watson, J. (2009). Does regular online testing enhance student learning in the numerical sciences? Robust evidence from a large data set. *British Journal of Education Technology*, 40(2), 255-272.

Macedo-Rouet M, Ney, M., Charles, S., & Lallich-Boidin, G. (2009) Students' performance and satisfaction with Web vs. paper-based practice quizzes and lecture notes. *Computers & Education*, 53(2),375-384.

Yates, R.W. & Beaudrie, B (2009). The Impact of Online Assessment on Grades in Community College Distance Education Mathematics Courses. *American Journal of Distance Education*, 23:2, 62-70.

APPENDICES

APPENDIX A

INITIAL SURVEY

As we discussed, with your consent, I will be collecting data on a project done in this classroom over the course of the semester. This is the first part of that, and as such, I will be asking for some background information as well as some questions about your previous mathematics experience and online learning experiences. Please remember that your participation is entirely voluntary, and that there will never be any academic benefit offered for participating, nor punishment for choosing not to participate.

Name: _____

How old are you? ____ What is your gender? ____

How many years have you been attending College of the Rockies? ____

How many years have you attended other Post-Secondary Institutions? _____

What was the last math course you took before this one? _____

Approximately how many other math courses have you had? (at or above the grade 11 level) _____

How long ago was the most recent course? _____

What was your grade in that course? _____

Have you used Moodle in any other courses at College of the Rockies? _____

I would like to perform some follow-up interviews with students, would you consent to being interviewed? Circle one please: **Yes** **No**

For the following questions, please circle the value that corresponds to how you feel about the statement given. The scale ranges from 1 (strongly agree with the statement) to 5 (strongly disagree with the statement) with a value of 6 for no opinion. There is room below each question to add comments.

1) I feel confident in my ability to use online learning resources

1	2	3	4	5	6
Strongly	Somewhat	Neutral	Somewhat	Strongly	No Opinion
Agree	Agree		Disagree	Disagree	

Why did you select the answer you did in the above question? _____

2) I feel confident in my mathematical abilities

1	2	3	4	5	6
Strongly	Somewhat	Neutral	Somewhat	Strongly	No Opinion
Agree	Agree		Disagree	Disagree	

Why did you select the answer you did in the above question? _____

3) I believe that if I put effort into my math work, I will achieve good grades

1	2	3	4	5	6
Strongly	Somewhat	Neutral	Somewhat	Strongly	No Opinion
Agree	Agree		Disagree	Disagree	

Why did you select the answer you did in the above question? _____

4) I enjoy online education and online educational resources

1	2	3	4	5	6
Strongly	Somewhat	Neutral	Somewhat	Strongly	No Opinion
Agree	Agree		Disagree	Disagree	

Why did you select the answer you did in the above question? _____

5) I feel like my grade in math is directly within my control

1	2	3	4	5	6
Strongly	Somewhat	Neutral	Somewhat	Strongly	No Opinion
Agree	Agree		Disagree	Disagree	

Why did you select the answer you did in the above question? _____

6) Math takes the same amount of time and effort as my other classes

1	2	3	4	5	6
Strongly	Somewhat	Neutral	Somewhat	Strongly	No Opinion
Agree	Agree		Disagree	Disagree	

Why did you select the answer you did in the above question? _____

7) There is a particular topic in math that gives me more trouble than other topics

1	2	3	4	5	6
Strongly Agree	Somewhat Agree	Neutral	Somewhat Disagree	Strongly Disagree	No Opinion

Why did you select the answer you did in the above question? _____

8) There is a particular type of question or problem that gives me more trouble than other types of questions

1	2	3	4	5	6
Strongly Agree	Somewhat Agree	Neutral	Somewhat Disagree	Strongly Disagree	No Opinion

Why did you select the answer you did in the above question? _____

9) I feel confident that my math experience has adequately prepared me for this class

1	2	3	4	5	6
Strongly Agree	Somewhat Agree	Neutral	Somewhat Disagree	Strongly Disagree	No Opinion

Why did you select the answer you did in the above question? _____

Is there anything else that you feel I should know about the class, your math ability or your experience in on line learning?

APPENDIX B

NON-TREATMENT SURVEY

This is the second part of the data collection, and as such, I will be asking some of the same questions, as well as a couple of additional ones. As we discussed, I ask the same questions I've asked before because I'm interested to see if your opinions and feelings have changed. Please remember that your participation is entirely voluntary, and that there will never be any academic benefit offered for participating, nor punishment for choosing not to participate.

Name: _____

I would like to perform some follow-up interviews with students, would you consent to being interviewed? Circle one please: **Yes** **No**

For the following questions, please circle the value that corresponds to how you feel about the statement given. The scale ranges from 1 (strongly agree with the statement) to 5 (strongly disagree with the statement) with a value of 6 for no opinion. There is room below each question to add comments.

1) I feel confident in my ability to use online learning resources

1	2	3	4	5	6
Strongly	Somewhat	Neutral	Somewhat	Strongly	No Opinion
Agree	Agree		Disagree	Disagree	

Why did you select the answer you did in the above question?

2) I feel confident in my mathematical abilities

1	2	3	4	5	6
Strongly	Somewhat	Neutral	Somewhat	Strongly	No Opinion
Agree	Agree		Disagree	Disagree	

Why did you select the answer you did in the above question?

3) I believe that if I put effort into my math work, I will achieve good grades

1	2	3	4	5	6
Strongly	Somewhat	Neutral	Somewhat	Strongly	No Opinion
Agree	Agree		Disagree	Disagree	

Why did you select the answer you did in the above question?

4) I enjoy online education and online educational resources

1	2	3	4	5	6
Strongly	Somewhat	Neutral	Somewhat	Strongly	No Opinion
Agree	Agree		Disagree	Disagree	

Why did you select the answer you did in the above question?

5) I feel like my grade in math is directly within my control

1	2	3	4	5	6
Strongly	Somewhat	Neutral	Somewhat	Strongly	No Opinion
Agree	Agree		Disagree	Disagree	

Why did you select the answer you did in the above question?

6) Math takes the same amount of time and effort as my other classes

1	2	3	4	5	6
Strongly	Somewhat	Neutral	Somewhat	Strongly	No Opinion
Agree	Agree		Disagree	Disagree	

Why did you select the answer you did in the above question? _____

7) There is a particular topic in math that gives me more trouble than other topics

1	2	3	4	5	6
Strongly	Somewhat	Neutral	Somewhat	Strongly	No Opinion
Agree	Agree		Disagree	Disagree	

Why did you select the answer you did in the above question?

8) There is a particular type of question or problem that gives me more trouble than other types of questions

1	2	3	4	5	6
Strongly	Somewhat	Neutral	Somewhat	Strongly	No Opinion

Agree Agree Disagree Disagree
 Why did you select the answer you did in the above question?

9) I feel confident that my math experience has adequately prepared me for this class

1 2 3 4 5 6
 Strongly Somewhat Neutral Somewhat Strongly No Opinion
 Agree Agree Disagree Disagree
 Why did you select the answer you did in the above question?

10) I feel that the assigned homework in this class adequately prepares me for the tests

1 2 3 4 5 6
 Strongly Somewhat Neutral Somewhat Strongly No Opinion
 Agree Agree Disagree Disagree
 Why did you select the answer you did in the above question?

11) The available online content (notes and lecture videos) is useful to me on a regular basis

1 2 3 4 5 6
 Strongly Somewhat Neutral Somewhat Strongly No Opinion
 Agree Agree Disagree Disagree
 Why did you select the answer you did in the above question?

12) I feel that the amount of time required for the assigned homework is reasonable

1 2 3 4 5 6
 Strongly Somewhat Neutral Somewhat Strongly No Opinion
 Agree Agree Disagree Disagree
 Why did you select the answer you did in the above question?

Is there anything else that you feel I should know about the class, your math ability or your experience in on line learning?

APPENDIX C

END OF SEMESTER SURVEY

This is the third and final part of the data collection, and as such, I will be asking some of the same questions, as well as a couple of additional ones. As we discussed, I ask the same questions I've asked before because I'm interested to see if your opinions and feelings have changed. Please remember that your participation is entirely voluntary, and that there will never be any academic benefit offered for participating, nor punishment for choosing not to participate.

Name: _____

I would like to perform some follow-up interviews with students, would you consent to being interviewed? Circle one please: **Yes** **No**

For the following questions, please circle the value that corresponds to how you feel about the statement given. The scale ranges from 1 (strongly agree with the statement) to 5 (strongly disagree with the statement) with a value of 6 for no opinion. There is room below each question to add comments.

1) I feel confident in my ability to use online learning resources

1	2	3	4	5	6
Strongly	Somewhat	Neutral	Somewhat	Strongly	No Opinion
Agree	Agree		Disagree	Disagree	

Why did you select the answer you did in the above question?

2) I feel confident in my mathematical abilities

1	2	3	4	5	6
Strongly	Somewhat	Neutral	Somewhat	Strongly	No Opinion
Agree	Agree		Disagree	Disagree	

Why did you select the answer you did in the above question?

3) I believe that if I put effort into my math work, I will achieve good grades

1	2	3	4	5	6
Strongly	Somewhat	Neutral	Somewhat	Strongly	No Opinion
Agree	Agree		Disagree	Disagree	

Why did you select the answer you did in the above question?

4) I enjoy online education and online educational resources

1	2	3	4	5	6
Strongly	Somewhat	Neutral	Somewhat	Strongly	No Opinion
Agree	Agree		Disagree	Disagree	

Why did you select the answer you did in the above question?

5) I feel like my grade in math is directly within my control

1	2	3	4	5	6
Strongly	Somewhat	Neutral	Somewhat	Strongly	No Opinion
Agree	Agree		Disagree	Disagree	

Why did you select the answer you did in the above question?

6) Math takes the same amount of time and effort as my other classes

1	2	3	4	5	6
Strongly	Somewhat	Neutral	Somewhat	Strongly	No Opinion
Agree	Agree		Disagree	Disagree	

Why did you select the answer you did in the above question?

7) There is a particular topic in math that gives me more trouble than other topics

1	2	3	4	5	6
Strongly	Somewhat	Neutral	Somewhat	Strongly	No Opinion
Agree	Agree		Disagree	Disagree	

Why did you select the answer you did in the above question?

8) There is a particular type of question or problem that gives me more trouble than other types of questions

1	2	3	4	5	6
Strongly	Somewhat	Neutral	Somewhat	Strongly	No Opinion

Agree Agree Disagree Disagree
 Why did you select the answer you did in the above question?

9) I feel that the assigned homework in this class adequately prepares me for the tests

1 2 3 4 5 6
 Strongly Somewhat Neutral Somewhat Strongly No Opinion
 Agree Agree Disagree Disagree
 Why did you select the answer you did in the above question?

10) I feel that the amount of time required for the assigned homework is reasonable

1 2 3 4 5 6
 Strongly Somewhat Neutral Somewhat Strongly No Opinion
 Agree Agree Disagree Disagree
 Why did you select the answer you did in the above question?

11) I prefer the online assignments to the written assignments

1 2 3 4 5 6
 Strongly Somewhat Neutral Somewhat Strongly No Opinion
 Agree Agree Disagree Disagree
 Why did you select the answer you did in the above question?

12) I prefer the written assignments to the online assignments

1 2 3 4 5 6
 Strongly Somewhat Neutral Somewhat Strongly No Opinion
 Agree Agree Disagree Disagree
 Why did you select the answer you did in the above question?

Is there anything else that you feel I should know about the class, the online or written assignments, the test material, or your experiences with online learning?

APPENDIX D

INSTITUTIONAL REVIEW BOARD CONFIRMATION



INSTITUTIONAL REVIEW BOARD
For the Protection of Human Subjects
FWA 00000165

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 c/o Immunology & Infectious Diseases
 Montana State University
 Bozeman, MT 59718
 Telephone: 406-994-6783
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Chair: Mark Quinn
 406-994-5721
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Administrator:
 Cheryl Johnson
 406-994-6783
 cherylj@montana.edu

MEMORANDUM

TO: Ben Heyde and Walt Woolbaugh
FROM: Mark Quinn, Chair *Mark Quinn*
DATE: December 20, 2012
RE: "The Effect of Online Assignments on Mathematics Learning?" [BH122012-EX]

The above research, described in your submission of December 17, 2012, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal regulations, Part 46, section 101. The specific paragraph which applies to your research is:

- X (b) (1) Research conducted in established or commonly accepted educational settings, involving normal educational practices such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.
- X (b) (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation.
- _____ (b) (3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.
- _____ (b) (4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available, or if the information is recorded by the investigator in such a manner that the subjects cannot be identified, directly or through identifiers linked to the subjects.
- _____ (b) (5) Research and demonstration projects, which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.
- _____ (b) (6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed, or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the FDA, or approved by the EPA, or the Food Safety and Inspection Service of the USDA.

Although review by the Institutional Review Board is not required for the above research, the Committee will be glad to review it. If you wish a review and committee approval, please submit 3 copies of the usual application form and it will be processed by expedited review.