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Cover Page Footnote

I would like to thank my colleagues (current and former) at Longwood University for their advice and suggestions on this work.

Improving Project Success in an Online Mathematics Course

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Abstract

With more mathematics courses migrating to online environments, it is important to know whether these courses are comparable to their face-to-face counterparts. To that end, in two different years, I taught an online and a face-to-face section of the same finite mathematics course. After analyzing the data regarding differences in the two sections for the first year, I incorporated changes intended to improve the consistency of project success between the two sections as well as the overall success of the class projects in the online section. My main tool was mimicking the interaction of group members and providing immediate instructor feedback in the early stages of project completion. Happily, I saw an increase in the success of the class projects in the online section.

1. Introduction.

Online classes aim to provide students with a sound foundation in the topics taught in the course while taking advantage of the asynchronous nature of the online environment. However, many instructors remain concerned about student success in these courses compared to face-to-face courses, and various accrediting bodies require evidence addressing that concern (see §2 for a brief literature review). In this article I highlight some factors that may help students succeed in class projects they complete for their online courses.

After teaching a finite mathematics course in face-to-face sections for eight semesters and over several summer sessions, I decided to teach the course fully online in the summer of 2008. In both Spring 2009 and Spring

2011, I taught two sections of this course, one online and the other face-to-face. My goal in Spring 2009 was to determine which aspects of the course (homework, quizzes, group projects, tests, final exam) had significantly different outcomes between the two sections. Based on previous experience and a cursory overview of the literature on online education, I expected that some of the averages of the online section would be significantly lower. In Spring 2011 my goal was to incorporate ideas that would (1) provide consistency between the averages in online and face-to-face sections, and (2) increase the averages in areas where the online section average was significantly lower. Based on Spring 2009 data, my second goal was particularly targeted at group projects. To try to achieve these goals, in Spring 2011 I altered both the interaction among group members as well as the interaction between group members and me.

Before teaching online for the first time, I participated in a special training program (Longwood Online Technology Institute, abbreviated henceforth as LOTI) at my institution. The goal of LOTI is to train instructors of online and hybrid courses about technological tools that could be used in one's courses as well as best practices in teaching. LOTI participants worked on syllabus design with the LOTI staff to ensure common issues in online courses were addressed. Participants also began initial work on course design so that staff could provide early feedback. Additionally, video recording and editing software as well as features within the course management system Blackboard were explored. Because many course management systems do not allow the user the ability to write algorithmic mathematical questions, LOTI could not focus on that aspect of my online courses. Nonetheless, I benefited significantly from LOTI because the program focused my attention on the structure and pacing of my course. It also sharpened my recognition that students might react differently to an assignment or a challenge online than in a face-to-face environment.

After LOTI participants complete their first online course, they are expected to reflect on strategies to improve their course. Thus the LOTI program reinforces a culture of improving one's teaching. In my own online summer section of finite mathematics, anecdotal evidence suggested that students had performed noticeably worse than those in previous face-to-face sections I'd taught, in particular on group projects and on tests. I could think of several potential reasons for the difference: the compression of the course into a short time frame, lack of student engagement in studying with others in the section, and lack of participation in the ancillary online study features. In order to clarify where the differences arose, I devised a more systematic approach to comparing success in these online and face-to-face courses.

2. Literature Review.

Student success in online courses has been studied from the standpoints of individual reflections by the faculty who teach them, sets of classes by the same professor(s), and larger group studies of faculty and/or students ([1], [11], [14], [21], [22]). Active learning within groups in online courses has been explored in various studies ([8], [12], [29]). Studies on statistics courses taught using technology from 1999–2009 repeatedly confirmed the importance of interaction between students and instructor and/or other students ([23]).

Many studies that focus on success of students in online courses are more concerned with general pedagogical principles, even when addressing mathematics ([16], [19]). Studies that have focused on the differences in success between face-to-face and online courses have for the most part found no difference in student success ([6], [10], [28], [30]). Less has been done to measure or address these differences in the context of an undergraduate mathematics course. Rey has done work analyzing the future success of those taking remedial courses as they begin college ([26]), and the use of online homework in both a lecture format and in online classes has been investigated ([9], [18], [24]). In a study addressing success in a business statistics class, Dutton and Dutton found that students in their online section performed better than their peers in a face-to-face class ([13]).

My work, while limited in scope, aims to quantify an improvement in a particular aspect of an online course. The principle of increased communication and a mix of synchronous and asynchronous interaction influenced project success. Indeed, the first two items of good practice in higher education ([7]) involve increased contact between students and faculty and cooperation among students. A recent article by Fernández describes her decision to incorporate enforced face-to-face testing, resulting in a hybrid (rather than fully online) mathematics course ([15]). While large differences in test scores between face-to-face and online students did not lead me to consider face-to-face testing, the value that Fernández places on interaction with students (both in testing and in answering student questions) echoes my focus on increased communication leading to an improvement in student success.

3. Course Content and Grading.

The three-credit finite mathematics course I taught covers a variety of topics associated to applications in business, selecting from topics such as linear and quadratic functions; Gauss-Jordan elimination; matrix algebra; solutions of inequalities; introductory linear programming; introductory probability and statistics; introductory game theory; and mathematics of finance. From 2004 to 2012, three sections of the course were typically offered during the regular academic year (with between 35 and 40 students per section) and one section was offered most summers (with about fifteen students). I taught the course numerous times before teaching it online, so it was a natural choice for my first online mathematics course.

I taught both a face-to-face and an online section of the course in both Spring 2009 and Spring 2011 semesters. A standard text was used in both semesters, with a newer edition used in the later semester ([2], [3]). Students were also required to purchase MyMathLab, a course management system for titles published by Pearson. This system allowed flexibility in writing algorithmic mathematical problems. The final grade for students in both semesters and in both sections of the course was determined as follows: 10% for each of the averages of the homework scores and the quiz scores, 12% from the four group projects (weighted equally), 15% for each of the three tests, and 23% for the final exam. Homework assignments were assigned from each of the text sections covered in the course. Quizzes were assigned through the MyMathLab system on a weekly basis (excluding weeks when there was a test). Students in the online section also completed the three tests and the final exam for the course using MyMathLab. Group projects were assigned and collected through the course management system Blackboard for both sections of the course.

Both sections were assigned homework and quizzes with questions from the pool of MyMathLab questions for the course text. MyMathLab individualizes problems by algorithmically generating different numerical values in each problem for individual students. The dates for initial availability and due dates for homework assignments and quizzes also coincided.

Students were also given exactly the same four group projects. These projects came from several sources, including modifications of projects from an older version of the text ([4]) and a finance project I had co-written together with a colleague. Groups consisted of three or four students chosen at random by me in advance. These students were then grouped together in Blackboard and given access to a group discussion board and a file exchange to transfer drafts of their projects.

Projects in both sections were graded by the same rubric. While eighty percent of an individual student's grade was based on correctness (content and grammar), ten percent of an individual student's grade was determined by whether that student had completed a group evaluation on all other members of her/his group; and ten percent of the grade was the average grade given to a student by the other members of her/his group on their evaluations. The peer evaluations by students were kept anonymous to encourage honesty in the assessment of the other group members' contributions, preparation, and attitude toward participation. I have taught mathematics courses both with and without peer evaluation of group projects. In concordance with a study finding this type of grading both fair and practical ([25]), I have found that students are less likely to "sweep a problematic group member under the rug," so to speak, when using peer review.

Students in the two sections received tests identical in terms of content. All three tests and the final exam consisted of short answer questions where students had to have both correct answers and correct justification to earn full credit. The tests and the final exam given to the face-to-face and online sections differed in two ways. First, students in the online section were allowed additional time on these exams. While face-to-face students were given fifty minutes to complete each of the three tests and one hundred fifty minutes to complete the final exam, students in the online section were given an hour to complete each of the three tests and three hours to complete the final exam. This 20% increase in time, a decision reached after consultation with LOTI program staff, was given to accommodate students in the online section who would use pencil and paper to work through the problems and additionally type their answers into the system to be graded.

The other difference in the two sections was that students in the online section could take an exam any time during the day it was given, while the face-to-face students took the exam during scheduled class time. Once a student started the exam in the online section, however, the student was not permitted to stop the exam partway through and restart it. The inability to stop and restart the assignment mimicked the timed quizzes given to both sections, although students could start or stop their homework assignments as often as they wanted before the due date.

4. Spring 2009: The Base Case.

Initially thirty-one students enrolled in the face-to-face section of the course and twenty students enrolled in the online section. However, by the end of the semester, one student had withdrawn from the face-to-face section and three students had withdrawn from the online section. The students who withdrew are not included in the statistical analysis that follows.

As is common in this type of situation, students self-selected the section of the course in which they wanted to enroll. One graduate student enrolled in the face-to-face course, while all other students in both sections of the course were undergraduates of typical college age; the undergraduates in the online course were full-time students at the university enrolled in other (face-to-face) classes there. A quick visual comparison of the GPAs from the previous semester (Fall 2008) shows that no significant difference exists in at least this measure; see Figure 1 below.

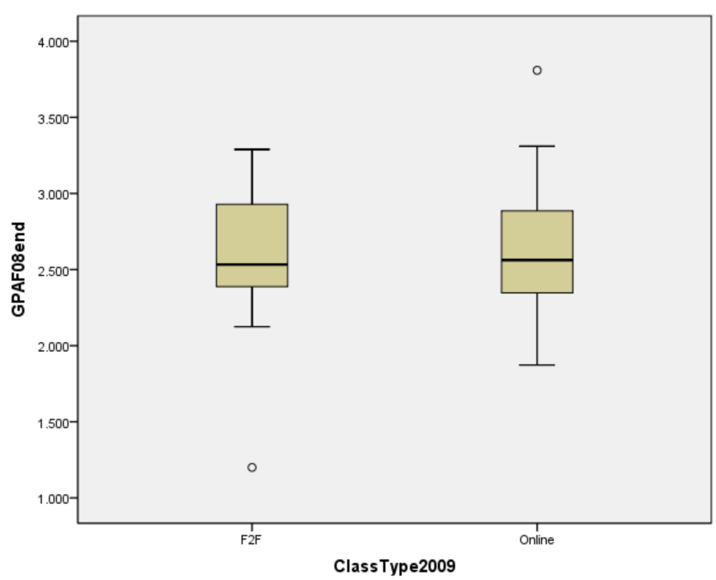

Figure 1: Boxplot of Fall 2008 GPAs for face-to-face and online Spring 2009 sections.

While the rubric for group projects and student assignment to groups was the same between the two sections, the initial distribution of the projects in Spring 2009 differed. In the online section, the project was posted to Blackboard for each group to view, and students were encouraged to ask questions (whether individually or as a group) to complete their work. In the face-to-face section, a class day was taken out for each project so that students could divide into groups to begin work on their projects. During that time, I circulated around the room to address any initial questions or difficulties that these groups encountered.

Glancing at the averages of the peer evaluations of group projects in Spring 2009 indicates that the online section's group evaluations were quite similar to those of the face-to-face section for three of the four projects. The third project shows a marked drop in the online section's group evaluations.

After the semester had concluded, I ran a multi-variable analysis of variance test (MANOVA) to determine if there were any differences in the five components of students' grades (homework, quiz, project, test, final exam) between the two sections.

The statistics for the samples are included in Table 1 below. Sample averages are listed above sample standard deviations in the last five columns.

		Average (out of 100%)				
Section	Number	Quiz	Homework	Project	Test	Final Exam
Face-to-Face	30	63.67% (23.49%)	81.28% (21.86%)	76.75% (11.65%)	62.53% (14.01%)	60.67% (22.80%)
Online	17	72.79% (23.93%)	83.81% (20.78%)	61.15% (15.53%)	47.73% (22.18%)	48.84% (29.46%)

Table 1: Spring 2009 averages.

The test performed on the above statistics yields the following significance levels:

	Average				
	Quiz	Homework	Project	Test	Final Exam
F	1.613	.700	15.251	7.886	2.358
p	0.211	0.700	0.000	0.007	0.132

Table 2: Spring 2009 statistical results.

No significant difference arises in the averages for the quiz, homework, or final exam. However, project averages and test averages differed significantly between students in the two sections.

5. Spring 2011: Implementing Changes.

Student comments for the Spring 2009 sections of the course indicated some concern about the difficulty of the group projects and the time given to take the tests. With these comments and the statistical evidence above, I sought to improve my students' success in the online section as well as ensure consistency between the two types of sections. In order to address the significant differences in the project averages, I mimicked the project distribution and the interactions in the face-to-face section. In particular, for each of the projects, each group was required to meet with me in the Wimba environment on Blackboard. Wimba is a virtual classroom environment that includes chat features as well as application and file sharing. In this environment, groups were able to gather online during a specified time to begin the project, while I was immediately available to answer initial questions.

In addition to mimicking the face-to-face environment, enforcing student interaction helps to ensure a broader network of peer support and assurance of instructor availability. These are qualities essential to building student support, an important aspect of increasing the success of students in an online environment ([17]). I found varying levels of interaction among group members in these online sessions, particularly during the meeting for the first group project. In future meetings, students exhibited a much clearer sense of purpose, and several groups even met with each other prior to the official meeting, in order to formalize initial questions about the project.

To address the different test averages, I posted a practice test on MyMathLab five days before the first test, and made it available to both sections of the Spring 2011 course. The practice test covered assumed knowledge (e.g., decimals, fractions, and proportions) and was meant to show online students the format of what the online test would look like.

Course content remained relatively stable between Spring 2009 and Spring 2011. Minor changes included less emphasis on the individual row operations of row reduction of a matrix and a corresponding increase in time at the end of the course spent covering material on measures of central tendency. All other topics remained the same.

Numerical values in the projects changed, but I made no other changes to the structure of the Spring 2011 courses; neither the types or weighting of the graded assignments changed.

No students withdrew from either section in Spring 2011. All students were undergraduates of typical college age enrolled in other (face-to-face) classes at the university. As seen in Figure 2 below, the Fall 2010 GPAs of the two sections showed no statistical difference.

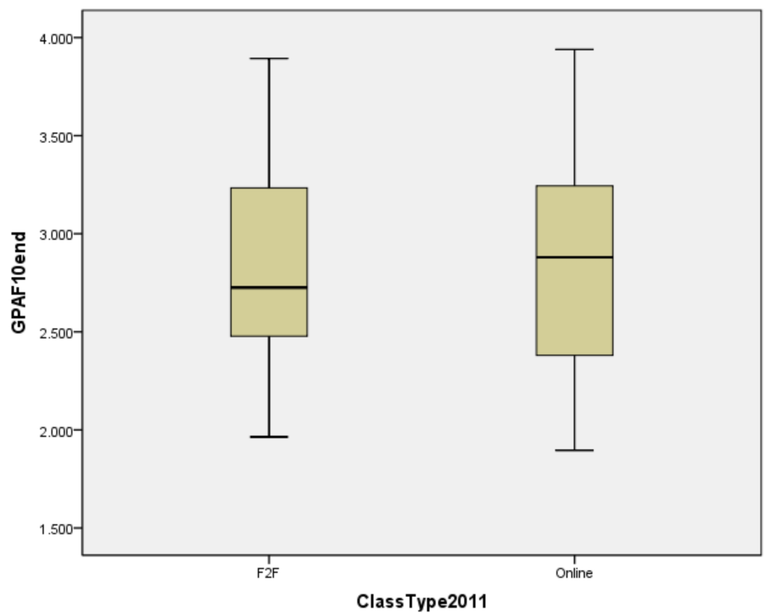

Figure 2: Boxplot of Fall 2010 GPAs for face-to-face and online Spring 2011 sections.

As in Spring 2009, a MANOVA test was run after the semester was done, both to evaluate any potential changes in the project and test averages due to changes in the course delivery and to confirm that the averages for the other aspects of the course remained similar. Descriptive statistics for Spring 2011 are displayed in Table 3, and the statistical test results appear in Table 4 below.

		Average (out of 100%)				
Section	Number	Quiz	Homework	Project	Test	Final Exam
Face-to-Face	37	78.39% (19.83%)	90.10% (13.74%)	80.10% (8.80%)	75.30% (11.16%)	74.99% (12.96%)
Online	30	82.96% (22.21%)	88.38% (18.71%)	73.66% (17.57%)	64.38% (14.53%)	61.79% (23.25%)

Table 3: Spring 2011 averages.

	Average				
	Quiz	Homework	Project	Test	Final Exam
F	0.792	0.187	3.806	12.109	8.638
p	0.377	0.667	0.055	0.001	0.005

Table 4: Spring 2011 statistical results

Again there is no significant difference in homework or quiz averages from the Spring 2011 sections. A significant difference again arises in the test averages between face-to-face and online sections. At the 5% significance level, the project averages for the two sections are not significantly different, while there is a significant difference between the final exam averages of the two sections.

6. A Discussion: Project Success in Online Sections

As mentioned earlier, one of my goals was to increase consistency of the outcomes of similar students enrolled in different sections of the same course. Although statistically significant, consistency of group project averages is less convincing from a practical viewpoint. This ambivalence is inconsistent with several previous findings about the success of face-to-face versus online students, which show no difference in success ([6], [10], [28], [30]).

While I achieved only limited success in improving the consistency of project scores, I was heartened to see an improvement of the overall project scores of the online section. Table 5 below gathers together project averages in the online sections from Spring 2009 and Spring 2011. As stated above, although some small changes were made to the numbers in the projects, their structure and content stayed essentially the same. Templates of the project solutions were not made available to the Spring 2009 students, and these projects were not used in any other sections of the course in the intervening time period. The average GPAs in Fall 2008 and Fall 2010 were not significantly different for students in the Spring 2009 and Spring 2011 online sections, respectively.

Section	Number	Project Average	Project Standard Deviation
Online 2009	17	61.15%	15.53%
Online 2011	30	73.66%	17.57%

Table 5: Online project summaries.

A 2-sample t-test strongly supports the claim that the project average for online students who receive group interaction via Wimba at the beginning of the project is greater than the project average for online students who do not ($t(45)$=-2.443, p=0.010).

This study shows quantitatively that the enforced interaction had a measurably positive effect on project scores. This method serves as a bridge between the strictly synchronous or strictly asynchronous communication for any particular aspect of a course. Faculty perceive both pros and cons in each technique ([20], [31]), while students have been shown to rate instructor presence in a real-time chat environment as less important than many other aspects ([27]). Nevertheless, this study underscores the value of a method which merges the potential for both synchronous and asynchronous methods of communication in a particular assignment.

A small step meant to help success in test averages for online students may or may not have led to a significant increase in those averages. There is strong evidence that the test average for the online students with a sample test is greater than the average of those who did not; however, the increase cannot be attributed solely to the sample test because of the slight change in topics from Spring 2009 to Spring 2011.

7. Conclusion

Scores on the group projects significantly improved in the online section by requiring early synchronous interaction among members of each group (with an instructor available to answer questions), even though the difference in average project score between face-to-face and online sections of the course did not display a significant change with this interaction added.

As a result, my main recommendation regarding online facilitation of projects is to employ both synchronous and asynchronous communication techniques even within one type of assignment. Relying on a dual approach allows students to receive immediate feedback to build confidence in their skills, interact directly with peers, and to take advantage of the extended time needed to digest ideas and struggle with concepts on their own schedule. Given that 72% of course projects are the same in undergraduate mathematics courses where sections are offered both face-to-face and online ([5]), a different method of implementation for course projects in online sections would prove valuable for student success.

The significant difference evidenced in Spring 2009 between the averages of the test scores was not so easy to address. Several avenues to address the continued differences in test scores between online and face-to-face sections of this course exist. One option is to provide targeted practice exams on the topics to be covered on an upcoming test, instead of simply having a practice test to address the format of an online exam. Another option is to reexamine how online students take an exam to determine the best extended time technique in this setting.

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