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Integrating Collaborative Online Grading Platforms into the Coordination of Calculus: A Case Study

A. Martina Bode

Abstract: This case study details the integration of an online grading platform in a Calculus program. Initially implemented to increase the efficiency and quality of grading written assessments in a large undergraduate program, the effects were many and surprising. Two main concerns surfaced that we needed to address, namely:

- consistency in grading;
- quality of feedback to students to facilitate learning.

With greater course coordination and the use of the online grading platform for homework and exams, student success in Calculus and retention of students continuing from Calculus I to II dramatically improved over the past 2 years.

Keywords: Online grading platforms, instructional technology, coordination of instruction, student success rates, DFW rates, retention of students in calculus, Calculus I, Calculus II

1. INTRODUCTION

The MAA National Study of College Calculus [1] in 2015 studied the key elements of success in Calculus programs. Calculus I is often taught in several sections by a wide range of instructors. Instructors might be tenure line faculty,

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Color versions of one or more of the figures in the article can be found online at www.tandfonline.com/upri visiting faculty, post docs, adjunct lecturers, or graduate students. In chapter 9 [4] of the study by Chris Rasmussen, San Diego State University, and Jessica Ellis, Colorado State University, Fort Collins, the authors explored the systems of coordination in calculus at five PhD-granting universities. They learned that it is not the existence *per se* of a common syllabus, textbook, and final exam, but rather something more nuanced in which both coordination and instructional independence are valued.

This case studies highlights changes in coordination, in particular the coordinated use of an online grading platform in Calculus.

2. BACKGROUND

The MAA National Study of College Calculus [1] revealed that Calculus I, as taught in our colleges and universities, is lowering student confidence, enjoyment of mathematics, and desire to continue in a field that requires further mathematics. Furthermore, a large percentage of students starting in Calculus I, intending to continue in Calculus II, change their mind and do not continue to Calculus II. Chris Rasmussen and Jessica Ellis [3] looked at the group of students intending to pursue a degree in a STEM discipline, but who at the end of Calculus I decided not to continue in Calculus II. Of those enrolled in a Calculus I program intending to continue to Calculus II, 12.5% changed their mind about continuing. Of these students, over 30% reported the decision not to continue in Calculus II is due to their Calculus I experience; another 29% reported that to continue in Calculus, they would have needed to expend more time and effort than they could afford.

In this case study, we looked at the Calculus program at a large public midwestern research university. The DFW rate is the rate at which students receive D-grades, F-grades, or Withdrawals in courses. In this study, the DFW rates in Calculus I were approximately 37% through Fall 2013. There was increasing concern that some students were not learning and were unprepared to be successful in Calculus II, yet they were passing Calculus I. In Spring 2014, it was decided that a C should reflect sufficient mastery of the material to go on to Calculus II, and stricter criteria for passing were implemented. This resulted in a 63% DFW rate in the Spring of 2014. It appeared that due to few assessments during the course, students did not know how they were doing in the course until they took the final exam.

In Fall 2014, teaching assistants were instructed to implement active learning with the use of worksheets and group work during recitation time. There were no assessments during recitation time, but students now were required to complete a weekly homework assignment. A random selection of problems were graded by hand each week to give students more feedback. The grading system was changed to a system with strict grade cutoffs, in part so that students would know their course standing throughout the course. Another change was the introduction of common midterms, creating common standards across all

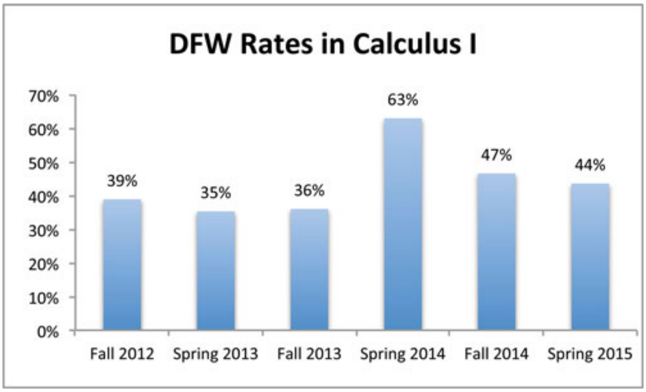


Figure 1. DFW rates in Calculus I from Fall 2012 through Spring 2015.

sections. The results in 2014–15 were good. The DFW rates were lower than in Spring 2014 but still above the original DFW rates of 37%, see Figure 1.

That same year, the search for a Director of Calculus as well as a Director of Pre-Calculus began. The work of the new directors resulted in strengthened coordination and in integration of instructional technology in 2015–16. In this case study, we will look at these changes in course coordination and integration of instructional technology in Calculus I and II. In particular, we will look at the use of online grading platforms.

3. STUDY DESCRIPTION

The university in this case study is a large, public, urban university. Calculus I and II are taught in several sections with an average section size of about 115 students. For example, Calculus I, Fall 2015, had an enrollment of about 1000 students, in eight sections taught by six different instructors and 20 teaching assistants. Instructors met with students three times a week in lecture halls; graduate teaching assistants met with students twice a week in small recitation sections of about 20 students.

Changes in 2014–15 included more coordination of course materials, common midterms and common grading, increased emphasis on written homework and multi-step problems. We also encouraged the integration of active learning in the recitation sections, in particular students working in small groups on worksheets, and students presenting their work to others. In addition, mandatory attendance policies and set grade cutoffs were put into place. As a result, the DFW rates in Calculus I decreased, but were still high.

Additional changes beginning in Fall 2015 included increased communication between instructors and with teaching assistants, the implementation of common course sites, the launch of online homework, the integration of active learning in the large lectures, and the use of online grading platforms.

The most important lessons we learned in 2016 were a result of the use of online grading platforms for grading written homework and exams. With the use of these grading platforms, we improved not only our productivity, but also grading consistency and feedback to students.

The DFW rates went from 47% in Fall 2014, to 27% in Fall 2015, to 26% in Fall 2016. Retention of Calculus I students continuing to Calculus II improved from 27% in 2014–15, to 38% in 2015–16, to 44% in 2016–17.

4. KEY CHANGES IN CALCULUS

Key changes in Calculus included the implementation of online homework and the grading of written homework in online grading platforms.

4.1. Common Course Elements and Course Meetings

We strengthened course coordination by putting more common course elements into place, and by merging all course components into a common course management site for each calculus course. In addition, we instituted frequent meetings with instructors and with teaching assistants.

4.2. Online Homework Systems

The common sites allowed us to launch common course components, such as online homework, written assessments, and media components, from a single site. Grades were collected in a grade book, allowing us to maintain course-wide data in one location. A weight of 15% of the final grade was assigned to online homework, giving students incentive to do the homework.

4.3. Written Homework

Online homework, even with recent advances, is mostly limited to multiple choice, matching, and numerical questions. Students cannot demonstrate their ability to present a problem in a logical, written way. Each week, a selection of these problems was assigned. Instead of collecting and grading the written homework by hand, we had students scan and submit their work electronically to an online grading platform. Written homework accounted for an additional 15% of the final grade. It was returned with detailed feedback to students via email from an online grading platform.

Table 1. Number of users.

	Users
Fall 2015	27
Spring 2016	105
Fall 2016	232
Spring 2017	429

4.4. Online Grading Platform

We started to use online grading platforms in Fall 2015. The popularity of the platform(s) can be seen by the growth of users. The data of users and assessments is provided by one of the grading platforms. The trend that we see in the data is that most users continue to use an online platform in their subsequent courses. The numbers of users, i.e., instructors, teaching assistants and graders, for one of the two grading platforms used in mathematics and physics at our university are listed in Table 1; we have about 20 users using the other platform.

The number of users grew from 27 to 429 users in mathematics and physics. They graded a total of 1287 assessments (exams or homework assignments), for 8100 students (each student counted only once even if they were in more than one course using online grading platforms), totaling 636,800 graded pages.

5. IMPROVEMENTS IN GRADING AND FEEDBACK TO STUDENTS AS A RESULT OF USING ONLINE GRADING PLATFORMS

An online collaborative grading and analytics platform, such as Crowdmark or Gradescope is a platform to grade written assessments. Assessments can be proctored written exams or assigned written work. The assessments are uploaded to a grading grid and the graders use computers to grade the written work. These grading platforms include tools to mark up the student work, as well as to add written comments that can be reused and personalized. Navigation from one student exam page to the same page of the next student is fast and easy. When grading is complete, students receive a link to view their graded exams. The student identity is unknown to the graders, and grading can be monitored remotely by instructors or the course coordinator. Incorrect grading can be regraded, and grading comments can be added even after exams have been returned. The performance and rate of each grader can be monitored.

Table 2. Average grading times.

	Graders	Exams	Average grading time (hours: minutes)
Calc I Fall 2015	25	965	4: 19
Calc II Spring 2017	17	441	3: 41

5.1. Academic Integrity

Editing of exams by students after grading is impossible. A small but important point!

5.2. Productivity

Overall, the flow and the monitoring of grading progress improved dramatically. The grading time decreased, encouraging graders to write more comments and to give more feedback to students. We found that most graders were giving more feedback than they would have done in grading the traditional way; however, some graders gave little or no feedback. A brief discussion usually convinced those graders to give more feedback. Experienced graders were able to grade from wherever they chose, avoiding large and long group grading sessions. Graded work was returned electronically to students, and thus did not take up class time.

Average grading times with online grading platforms varied, see Table 2. For example, average grading time of Calculus I and II final exams was 3 to 5 hours per grader, compared with past grading sessions of 5 to 8 hours. That pages did not need to be flipped and that all exams were in one location sped up the grading process considerably.

See [2] and [5] for studies on grading productivity.

The grading data was available to all graders, allowing the course coordinator, as well as the whole grading team, to monitor progress. The grading rate (pages per hour) of each grader was displayed. Grading rates varied between 50 and 200 pages per hour. The rate depended on the grading difficulty of the material, and the thoroughness and general speed of the grader. We used the grading information to move graders to problems that required more graders, to check the grading quality of fast graders, to work with slow graders to improve grading strategies, and to estimate the overall grading time. This information was also useful to the course coordinator in assigning and monitoring the grading of subsequent exams.

5.3. Detailed Feedback

Students receive a link to access and review their graded work electronically. Grading in online grading platforms allows the easy use and reuse of grading comments, an efficient way to provide more detailed feedback to students. Performance statistics for each problem or page are automatically created by online grading platforms, providing information on the score distribution of problems. In addition, instructors can easily access student work electronically to review the performance of a particular student. Without an online grading platform, the extensive grading of written assignments with detailed feedback to students would not be possible.

We saw an increase in feedback on written assessments as well as on exams. In the past, grading rubrics for written homework assignments and exams were were posted for students, with few or no comments on individual work. With the grading platforms, most graders wrote short comments and reused these comments to give feedback to students. There were some graders who wrote long comments, and a few graders who chose to leave no comments for students. We received emails from students when graders subtracted points without any comments. We then asked some graders to go back through their grading and enter comments. In almost all cases, these graders included comments on subsequent assessments.

5.4. Grading Consistency

We were aware of some degree of grading inconsistencies from the *occasional* requests of students to regrade a problem on an exam, but we were surprised by the extent of this problem. The grading grid contains all of the exams. It is easy for instructors to navigate the grid to recheck and regrade at any time, even after the exam is returned to the student.

In Fall 2015, the first term of use of online grading platforms, the problem of grading inconsistencies surfaced on all types of assessments, exams and written homework. This occurred in nearly all the in mathematics and physics courses that used an online grading platform. To explain the extent of this problem, here is a representative example from Calculus I, Fall 2015, giving the number of problems that needed to be regraded due to grading inconsistencies or deviations from the grading rubric:

- Exam I: Four out of eight problems regraded.
- Exam 2: Two out of eight problems regraded.
- Final Exam: No problems regraded, the grading was monitored by instructors for consistency throughout the grading progress.

Similar problems surfaced with the grading of written homework assignments, in particular homework assignments that were partly graded by paid undergraduate students. Physics reported similar challenges in grading inconsistencies.

In the 2 years of using online grading platforms, consistency in grading continues to improve; yet, we continue to encounter grading challenges. Most of our grading challenges fall into the following categories:

1. The interpretation of grading rubrics; specifically, the variation in interpretation of the same rubric by individual graders.
2. The grader that is inconsistent with his/her grading.
3. The grader that enters scores, but does not provide any feedback for students. This continues to be a problem.

We have learned to set aside more time to oversee the grading, looking for consistency and for quality of feedback to students. More importantly, however, we are working to write better rubrics and to communicate them clearly to graders.

5.5. Grading Rubrics

We are using two competing online grading platforms, the more widely used is platform A (429 users 2015–17), and platform B, with approximately 20 users. Platform B has the option of creating reusable grading rubric items. Each rubric item has a score assigned that can be changed later if necessary. Graders using platform B who have previously used the other platform, have reported that productivity is superior to platform A. There are many advantages of using rubrics. Students can see why they lost points even if graders do not make any comments; more importantly, these rubrics improve grading consistency, as rubric items have to be chosen to assign scores.

The advantage of competing platforms is that the developers are eager to implement features that have proven to be successful on the competitor's platform. Thus, we expect both grading platforms to offer more features in the near future.

5.6. Challenges using Online Grading Platforms

How difficult is it to use these platforms? Learning how to grade is straightforward; the challenge is to set up the exam for grading, which includes the printing and the scanning of the exam. On Final Exam day (most common math exams are given on the same day), we use two copiers and two fast scanners for the scanning of exams; in the Fall this can add up to about 4000 exams being scanned in on the same day.

It is advisable that anyone starting to use an online grading platform contact a current user to learn about the most common problems with the specific platform. We spent many hours and days during our first round of exams fixing printing and scanning problems.

Another challenge is the exponential growth of users of the product. The grading platforms can be slow to adjust to the number of users during peak exam times.

Table 3. Breakdown of DFW rates into individual components (unit: %).

Term	F 14	S 15	F15	S 16	F 16	S 17
D	18	16	13	7	12	18
F	10	9	7	8	7	11
W	18	19	7	8	7	12

6. DATA

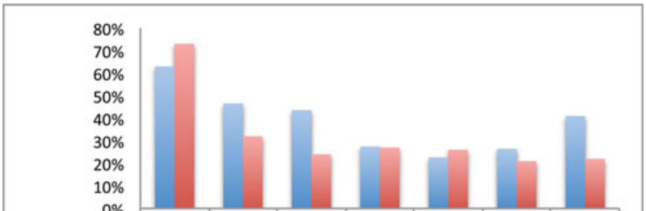
Student Success rates have been on the rise since the instructional changes were implemented in 2014–15, and increasingly so with the coordination and introduction of instructional technologies in 2015–17.

6.1. DFW, Passing Rates, & Student Confidence

Traditionally the DFW rates were approximately 37% in Calculus I and approximately 40% in Calculus II. DFW rates reached a high in Spring 2014. Then, except for a singular spike in the DFW rate in Calculus I in Spring 2017, DFW rates continually decreased. The reason for the spike in Calculus I, Spring 2017, has not been determined, but a contributing factor may be the difficulty of scheduling regular meetings of instructors and teaching assistants.

We can see a large drop in W rate in Calculus I comparing Fall 2014 with Fall 2015 and 2016, and Spring 2015 with Spring 2016 and 2017, see Figure 2 and Table 3.

In fact, the withdrawal rates in Calculus I are less than half in Fall 2015 and 2016 compared with Fall 2014. Even with the spike of DFW rates in Spring 2017, we see a significant drop in Ws in the Spring 2016 and 2017 compared



	Spring 2014	Fall 2014	Spring 2015	Fall 2015	Spring 2016	Fall 2016	Spring 2017
Calculus I	63%	47%	44%	27%	23%	26%	41%
Calculus II	73%	32%	24%	27%	26%	21%	22%

Figure 2. DFW rates in Calculus I and II.

Table 4. Student performance in Calculus II.

Year	# of students (% of Calc I students)	Passing Calculus II with a C or above	Passing rate (%)
2014–15	260 (27)	213	82
2015–16	388 (38)	301	78
2016–17	336 (44)	286	85

with Spring 2015. This may indicate that students in 2015–17 are more confident and less likely to withdraw from the course. This might be a result of students receiving more feedback on their overall standing in the course based on their performance on online homework, as well as improved feedback on assessments administered by the online grading platforms. The detailed grades on multiple assessments and fixed grade cutoffs help students to access their overall standing in the course throughout the term.

6.2. Retention

How many students continue from Calculus I to Calculus II? In 2014–15, 26.9% of Fall Calculus I students continued with Calculus II the following semester. A year later, in 2015–16, 38.2% of Fall Calculus I students continued with Calculus II. This is a total increase of 50% in students taking Calculus I and II consecutively. The trend continued in 2016–17 with 44.4% of students continuing from Calculus I to Calculus II, see Figure 3. In Rasmussen and Ellis [3], the problem of students changing their mind about continuing from Calculus I to Calculus II was studied. Although we have not studied how many of our

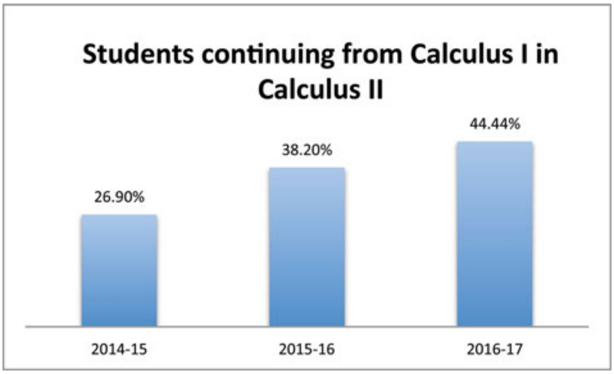


Figure 3. Students from Calculus I in the Fall continuing in Calculus II in the Spring.

Table 5. Passing rates (unit: %).

	All students in Calc II	Students from Calc I
Spring 2015	75	82
Spring 2016	74	78
Spring 2017	78	85

students are changing their mind, we can see that the percentage of students continuing in Calculus II increased from 26.9% to 44.4% in the 2-year period.

With more students continuing in Calculus II from Calculus I, how are these students performing in Calculus II? How well does Calculus I prepare students for Calculus II?

6.3. Passing Rates in Calculus II

The percentage of students taking Calculus II in the Spring after completing Calculus I in the Fall increased from 27% to 44%, see Table 4.

The passing rate of students in Calculus II in the Spring following Calculus I in the previous semester are generally higher than the passing rates of all students in Calculus II, see Table 5.

Thus, significantly more students are continuing in Calculus II and doing so successfully.

7. SUMMARY

We initially implemented an online grading platform in our Calculus program to improve grading efficiency and to provide more feedback to students. The grading efficiency improved immediately. The incorporation of this technology, however, showed us that our grading needed improvement. The use of the platform allowed us to monitor the grading more closely, which led to improvements in the quality of grading, grading consistency and higher quality feedback to students.

With greater course coordination and the use of the online grading platform for homework and exams, over the past 2 years, we experienced dramatic improvements in student success in Calculus and in retention of students continuing from Calculus I to II.

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BIOGRAPHICAL SKETCH

A. Martina Bode received her Ph.D. from Brandeis University in 1996 in Algebraic K-theory. Her current research interests include the effectiveness of active learning methods, the impact of strengthened coordination of calculus programs on student success and retention, and flipping of coordinated instruction. She is the Director of Calculus at UIC, and a member of the Developmental Math Task Force, which is a part of the Student Success Initiative. Previously, she was Director of Calculus and Distinguished Senior Lecturer at Northwestern University involved in teaching, mentoring of students, and initiatives to promote learning and teaching. Martina Bode has taught at Brandeis, Tufts, Wellesley, and Harvard Universities. During her 15-year career at Northwestern she earned over a dozen awards, including the Northwestern WCAS Teaching Alumni award, the Northwestern Charles Deering McCormick University Distinguished Lecturer Award, the Best Practices University Excellence Award, and the Campus Partner Award from Student Affairs. At UIC she was a Master Teaching Scholar for 2 years of the Teaching and Learning Communities founded in October of 2015.