

WIP: Standards-based Grading in Calculus with Precalculus

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Abstract—This innovative practice WIP paper on undergraduate education assessment describes the implementation of a standards-based grading system into Calculus with Precalculus. Standards-based grading is a way to structure the assessment of a class around the completion of a set of “standards,” with an emphasis on students having opportunities to reassess standards throughout the course. Calculus with Precalculus is a two-semester course that intermingles the topics of Precalculus and Calculus (completing both semesters is equivalent to Calculus I). Students take this class because it is a requirement for their major. The most common majors in the class are Biology, Mechanical Engineering, Biomedical Engineering, and Computer Science. In the standards-based grading system, we determine the “skills” that we want our students to learn by the end of the semester. The completion of these skills is 60% of a student’s grade (with the rest of a student’s grade determined by homework and a final exam). Each skill appears on three quizzes in a row, and to complete a skill a student needs to solve its quiz questions correctly two times. Once a skill stops appearing on the quizzes, students can still complete it by doing “retakes”. Given our students’ diverse backgrounds and preparation levels, the system works well for them. If a student completes a skill after two quizzes, they can skip that question on the third quiz. This lets them focus more on the skills they are struggling with. Students appreciate being able to come in and get help on (and retake) those skills. Instead of having this class act as a “gatekeeper” to Biology, Engineering, and Computer Science, both combining Calculus with Precalculus and using standards-based grading helps students of all backgrounds learn the material and succeed in the class. This type of standards-based grading system can be applied to classes from other disciplines as well.

Index Terms—standards-based grading, alternative grading, calculus, precalculus

I. INTRODUCTION

Standards-based grading is a way to structure the assessment of a class around the completion of a set of “standards.” Reference [1], describes standards-based grading as “a method of grading in which course content is divided into discretely assessable standards, and course grades are assigned based primarily on the number of standards a student masters... One essential feature of these grading schemes is providing students with opportunities to reassess their mastery of a given standard and improve their grade, thus lowering the stakes of any particular assessment.” Standards-based grading is used in many different courses including physics ([2]), chemistry ([3], [4]), engineering ([5], [6], [7]), statistics ([8], [9]), and

mathematics ([10]). A scoping review of the literature on alternative grading (which included standards-based grading) found that many of the studies reported that alternative grading had a positive impact on student learning and student attitudes [11].

One reason for using standards-based grading is to help students with test anxiety. Reference [1] found that standards-based grading was beneficial to students with test anxiety. However, students with “communication apprehension” were less likely to come to office hours to do reassessments [1]. In [12], they found that students had less test anxiety in standard-based grading courses.

When looking at the “STEM-penalty” (the difference between a student’s GPA in their STEM classes and non-STEM classes), students’ STEM GPAs are lower, especially in their first couple of semesters [13]. In particular, women had a higher “STEM-penalty” than men [13]. It is possible using an alternative grading practice could help students persist in STEM.

In this paper, we will be describing the standards-based grading system we use in Calculus with Precalculus at a private, comprehensive Catholic university with 2,700 undergraduate students.

II. SYSTEM DESIGN

A. The Courses

Calculus with Precalculus is a two-semester course that is equivalent to Calculus I. The first semester includes a review of functions, including polynomial and rational functions, limits, differentiation of algebraic functions, and applications of differentiation. The second semester begins with an introduction to integration (including u -substitution) and continues to apply the study of differentiation and integration to exponential, logarithmic, and trigonometric functions. Each course meets three days a week and each class meeting is 75 minutes long. There are typically 20-35 students per course. The textbook for both courses is *Calculus I with Precalculus, A One-Year Course, Third Edition* by Larson and Edwards [14].

The majority of students take these courses because they are required for their major. The most common majors in the classes are Biology, Mechanical Engineering, Biomedical Engineering, and Computer Science. Students take the two-semester Calculus with Precalculus over the one-semester

Calculus I for a variety of reasons: they have never taken a Precalculus course, their score on the directed self-placement test was below the minimum requirement for Calculus I, or they are anxious about taking Calculus and thus opt to take the version that is less fast-paced.

We will detail below the specifics of the standards-based grading system we use in Calculus with Precalculus. These ideas can be modified as an instructor wishes to suit their own courses.

B. Skills

We use the term “skills” for the standards of the course. We start by determining the skills we want our students to learn throughout each course. We currently have 37 skills in each course, although these continue to be refined from year-to-year. The objectives listed at the beginning of each section of the textbook are very helpful for determining the specific skills for the course. Some examples of skills are:

- Find the domain or range of functions.
- Determine intervals on which functions are increasing or decreasing and determine the relative maximum and relative minimum values of functions.
- Evaluate a limit using algebraic manipulations.
- Find the derivative of a function using the Product Rule.
- Use u -substitution to evaluate a definite integral.
- Use logarithms as an aid in differentiating nonlogarithmic functions.
- Find the derivative of trigonometric functions.

C. Assessment

We use weekly quizzes to assess skills. Each question tests a specific skill and the total number of skills on a quiz varies each week (on average, there are 7 skills on each quiz). An example of a question is:

- 1) Find the derivative of the following functions.
 - a) (Skill 27) $y = (x^3 - 2x + 5)(x^4 + x^2 + 3)$
 - b) (Skill 28) $y = \frac{t^3 + 3t}{t^2 - 4t + 3}$
 - c) (Skill 29) $y = (x^2 + x + 1)^5$

Each part of this question tests a different skill (product rule, quotient rule, and chain rule for derivatives, respectively).

Each skill appears on three consecutive quizzes. To complete a skill, a student needs to get a perfect score on its question on two quizzes. If a student completes a skill before the third quiz (e.g., they get a perfect score on Skill 20 on Quiz 6 and Quiz 7), they can skip that skill on the third quiz (e.g., they can skip Skill 20 on Quiz 8). Students keep track of their progress on the skills using a “scoresheet” we hand out at the beginning of the semester. We also use “Outcomes” and “Rubrics” in Canvas (our learning management system) as a way for students to keep track of their progress. Each skill is graded on a three point scale:

- 3 points: problem is correct without any errors
- 2 points: significant progress is made in the problem, but there are some minor errors

- 1 point: some progress is made in the problem, but there are some major errors
- 0 points: no progress is made in the problem (student did not attempt it)

Completing the skills is 60% of a student’s grade with online homework (we use WebAssign) being 15% and a cumulative final 25%. The final exam is not broken down by skills like the quizzes, and while some of the questions are similar to those on the quizzes, there are also questions that focus on combining skills and students’ understandings of the concepts.

To determine a student’s grade on the skills, we use the following formula:

$$\frac{(\# \text{ of two 3s}) + 0.5(\# \text{ of one 3}) + 0.1(\# \text{ of 2s}) - 0.2(\# \text{ of 0s})}{37}$$

Students get full credit for the number of skills that they have completed by getting them correct twice (# of two 3s). Students get half credit for any skills in which they only scored one 3 (+0.5(# of one 3)). Students get a small amount of credit for any skills on which they only scored a 2 (+0.1(# of 2s)). Finally, students lose credit (-0.2(# of 0s)) for any skills they have a 0 on at the end of the semester (to encourage students to attempt all the skills). We use this same formula to keep track of a student’s progress throughout the semester, but we only look at the skills that have “fallen off” the quizzes. For example, say skills 1-10 are no longer on the quizzes. We’ll calculate a student’s current score on the skills using the formula:

$$\frac{(\# \text{ of two 3s}) + 0.5(\# \text{ of one 3}) + 0.1(\# \text{ of 2s}) - 0.2(\# \text{ of 0s})}{10}$$

This score is then entered in the online grade book so students can see how they are doing overall. It is updated weekly as more skills “drop off”. We have created an Excel spreadsheet to streamline this weekly update.

D. Retakes

Once a skill has stopped appearing on the quizzes, students can still work on it by completing “retakes.” Students can complete retakes by coming to office hours. We also have an option for students to request retakes in class after they finish the current week’s quiz (making retakes accessible to students who cannot come to office hours). We do not limit the number of times a student can retake a skill, but we do suggest limiting the number of retakes a student can do at one time. It is also useful to have a deadline for the retakes (for example, two weeks since the skill was last on a quiz) so students do not wait until the end of the semester to attempt all their retakes.

III. PRELIMINARY RESULTS

The Calculus with Precalculus sequence has been taught exclusively using this standards-based grading system since 2018. Given the small classes and limited amount of pre-system data, we are not able to present grade data at this time to show the effectiveness of the system. However, we can give some observations and student comments. First, because students can do retakes on the skills until they learn them, we

have seen that students who fail the class (earn a D or an F) do so because they are not doing the work (either not coming to class to take the quizzes and/or not doing retakes).

In course evaluations, when answering “What 2-3 things did you like most about this course and find most useful or valuable for learning?”, students often comment about the skills. One wrote, “I really loved that instead of having exams we had weekly quizzes! I was really able to understand the material a lot better as I’m a horrible test taker and it was easier to study a few things for a quiz, than a bunch for an exam like other classes. I also loved being able to do retakes on skills.” Other comments included: “Weekly quizzes and retakes made it easy to not fall behind” and “We could retake quizzes at almost every opportunity.”

IV. FUTURE PLANS

After getting IRB approval, we plan to collect qualitative data by interviewing students in the course about their experiences with the standards-based grading system. We also plan to compare how students who took Calculus with Precalculus compare to students who took Calculus I in future Calculus classes. Previously Calculus II and Multivariable Calculus were only offered every other year at our institution. These courses were primarily taken by mathematics majors and minors (who mostly all took Calculus I). With the development of several new majors that require Calculus II and Multivariable Calculus, we have seen demand increase enough that we will now offer Calculus II every semester and Multivariable Calculus once a year. The students taking these classes will now be more evenly mixed between the students who took Calculus with Precalculus and the students who took Calculus I, so we can start to look at if there are any differences in the performances of these two groups. To do this, we will look at the overall grade distributions of the two groups as well as the grade distributions on each exam.

V. CONCLUSION

Our goal in this paper is to give an example of a standards-based grading system that one could use in their own courses. The type of grading system can be set up in a variety of classes. The first time using it does take extra preparation. One needs to write three questions for each skill for the quizzes and create a bank of retake questions for each skill. However, we find using the 3-point scale makes grading the quizzes easier and gives us more time to provide feedback.

Given our students’ diverse backgrounds and preparation levels, the system works well for them. If a student completes a skill after two quizzes, they can skip that question on the third quiz. This lets them focus more on the skills they are struggling with. Students appreciate being able to come in and get help on (and retake) those skills. Instead of having this class act as a “gatekeeper” to Biology, Engineering, and Computer Science, both combining Calculus with Precalculus into a two-semester course and using standards-based grading helps students of all backgrounds learn the material and succeed in the class.

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