

# PRIMUS

PRIMUS

Problems, Resources, and Issues in Mathematics Undergraduate Studies

ISSN: 1051-1970 (Print) 1935-4053 (Online) Journal homepage: [www.tandfonline.com/journals/upri20](http://www.tandfonline.com/journals/upri20)

## Second Chance Grading: An Equitable, Meaningful, and Easy-to-Implement Grading System that Synergizes the Research on Testing for Learning, Mastery Grading, and Growth Mindsets

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**To cite this article:** Oscar E. Fernandez (2021) Second Chance Grading: An Equitable, Meaningful, and Easy-to-Implement Grading System that Synergizes the Research on Testing for Learning, Mastery Grading, and Growth Mindsets, PRIMUS, 31:8, 855-868, DOI: [10.1080/10511970.2020.1772915](https://doi.org/10.1080/10511970.2020.1772915)

**To link to this article:** <https://doi.org/10.1080/10511970.2020.1772915>



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Published online: 12 Jun 2020.



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# Second Chance Grading: An Equitable, Meaningful, and Easy-to-Implement Grading System that Synergizes the Research on Testing for Learning, Mastery Grading, and Growth Mindsets

Oscar E. Fernandez

## ABSTRACT

This article describes the synthesis of the research on mastery grading, growth mindsets, and testing for learning to produce a new grading system – Second Chance Grading. The system and the research it is based on are described in detail. Reflections of the system's effectiveness, impact, and reception are also discussed. Finally, the appendix to the article contains an F.A.Q. section addressing some of the common questions and concerns related to the system.

## KEYWORDS

Mastery grading; growth mindset; inclusive teaching; test-enhanced learning

## 1. INTRODUCTION

In late 2015 I delivered a presentation titled “Research-Based Strategies for Closing the Achievement Gap in the Sciences” to the science faculty at Wellesley College, where I teach. While conducting the literature search for the presentation I came across research that would forever alter how I teach and how I grade – the literature on *growth mindsets* and *mastery grading*. I discuss that literature in more detail in [Section 2](#), but here are succinct definitions of the terms:

- Growth mindset: “Individuals who believe [human] attributes [(e.g., intelligence)] are stable have *fixed mind-sets* . . . whereas those who believe attributes are malleable have *growth mind-sets*” [21].
- Mastery grading: “[A]n approach to student assessment in which students are provided clear learning objectives, and grades are directly based on students’ ability to demonstrate full mastery of these objectives” [5].

Reading the research on growth mindsets and mastery grading got me worried. Was my then grading system – consisting of the typical high-stakes exams altogether worth more than half a student’s final grade – unfair to students with gaps in prerequisite knowledge, creating anxiety in my classrooms, and actively *discouraging*

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*learning* by promoting a “you either knew it at the time of the exam or you did not” mentality? This was not the environment I wanted to teach in, let alone promote, so I resolved to design a new grading system free of these issues. I settled on six main objectives for the new system:

- (1) Minimize students’ anxiety about their grades
- (2) Promote a growth mindset
- (3) Measure learning more accurately than my old grading system
- (4) Be more equitable, in that the system should not inadvertently make it harder for some groups of students (e.g., underrepresented students) to succeed than others
- (5) Be simple in structure
- (6) Be easy to implement and manage

I spent about one year designing the system, and in late 2016, Second Chance Grading was born.

The remainder of this article describes the research literature Second Chance Grading is based on ([Section 2](#)), the system itself and how it addresses the objectives above ([Section 3](#)), and personal reflections and data on the system’s effectiveness, reception, and impact after having used it in all of my courses since Summer 2017 ([Section 4](#)). The appendix contains a Frequently Asked Questions section addressing common concerns, suggestions, and questions about the system I have encountered from both students and faculty, as well as a sampling of the assessments I use in Second Chance Grading.

I designed Second Chance Grading with my mathematics courses in mind. However, I describe here its implementation in a manner that makes it possible to deploy in many non-mathematics courses. As we all stress constantly to our students: *please reach out to me if you have any questions, comments, or suggestions.*

## 2. THE RESEARCH SECOND CHANCE GRADING IS BASED ON

While not intended to be a comprehensive review of the research literature, this section summarizes the research that informed the design of Second Chance Grading. For my purposes here, let me categorize that research along the following dimensions:

- High-stakes versus low-stakes testing
- Frequent versus infrequent testing
- Formative versus summative assessments

*Research on high-stakes vs. low-stakes testing.* High-stakes testing has generally been found to produce significantly more test anxiety than low-stakes testing [[17](#), [20](#), [23](#)]. This is a particularly troubling finding given the high correlation ( $r = 0.52$ ) between test anxiety and mathematics anxiety [[1](#), Table 18.1] and the fact that

“there is significant evidence that mathematics anxiety interferes with performance of mathematical tasks” [6]. Worse yet, research shows that high-stakes testing has adverse impacts on identity-threatened groups [3] and underrepresented students [14], and may promote gender gaps in education [4].

*Research on testing frequency.* The *testing effect* – “the fact that active retrieval [(i.e., testing)] produces better retention than passive rereading” [19] – is well-documented in the research literature. Additional work even suggests specific ways to leverage the testing effect. For example, research shows that frequent testing raises achievement scores (and even leads to students rating their instructors more favorably) [2, 19]. In addition, research shows that shorter tests boost performance – the studies reviewed in [2] conclude that “superior performance was obtained from students who answered the questions [(test questions)] on a large number of short tests rather than on a small number of long tests.”

In addition to breaking up a high-stakes test into smaller low-stakes tests, researchers advise structuring tests as learning opportunities, a practice known as *test-enhanced learning*. As [3] notes: “In science classrooms, it may therefore be particularly important to consider approaches to test-enhanced learning that are no- or low-stakes and are articulated as learning opportunities, thereby minimizing the potential for stereotype threat.” This approach makes tests more like *formative assessments* – which *monitor* student learning – and less like *summative assessments*, which *evaluate* student learning. Formative assessments are the hallmark of mastery grading systems, which we now briefly review.

*Research on mastery grading.* The definition of mastery grading referenced in the Introduction is an umbrella term. There exist many variants of mastery grading, such as *standards-based grading* and *specifications grading* (see [5] for definitions), but as pointed out in [5], mastery grading schemes generally share three common features:

- Objectives are clearly articulated. Example: “Topic 1 will test your ability to successfully factor quadratic polynomials.”
- Students are assessed based on their mastery of the objectives. Many instructors use a “scoring scale” like M, G, P, X, which stand for Mastered, Good, Proficient, and No Basis to Judge (X), often reserved for work not turned in.
- Students are given multiple opportunities to demonstrate mastery, and not penalized for previously unsuccessful attempts at mastery.

A student’s final grade is then calculated based on how many objectives they mastered (the exact formulas vary).

Research suggests that mastery grading generally raises academic achievement. As documented in [22], “Haystead and Marzano [11] conducted a comprehensive review of studies on classroom instructional strategies, concluding the use of scoring scales and tracking student progress over time towards a learning goal yielded a 34 percentage point gain.” Moreover, some research documents impressive results from using mastery grading. For example, a large 2015 study of 11 Kentucky high

schools found that “the rate of students earning an A or B in a course [(an Algebra 2 course)] and passing the state test approximately doubled when utilizing standards-based grading practices” and that “standards-based grading practices identified more predictive and valid assessment of at-risk students’ attainment of subject knowledge” [18].

Mastery grading schemes naturally encourage students to become more mastery-oriented. This (almost) self-evident claim has important ramifications when one consults the literature on growth mindsets.

*Research on growth mindsets.* Carol Dweck’s research on growth mindsets [7] suggests that “what students believe about their brains – whether they see their intelligence as something that’s fixed or something that can grow and change – has profound effects on their motivation, learning, and school achievement” [8]. Specifically, research by Dweck and others suggests that “students who believe their intelligence is malleable [(growth mindset)] have higher levels of achievement than those who believe it is fixed [(fixed mindset)]” [16]. In the review [16] the authors identify the key role that mastery-oriented children played in the development of Dweck’s ideas. Such students used self-monitoring, self-instructing, and failure feedback strategies to help them achieve greater academic achievement than their non-mastery-oriented peers. (Mastery grading schemes provide this feedback naturally.) Recent research on interventions designed to promote growth mindsets is generally positive. The recent meta-analysis of growth mindset research [21], for example, finds “significant [positive] effects for academically high-risk students and low-SES [socioeconomic status] students.” (The report *Why So Few? Women in Science, Technology, Engineering, and Mathematics* by the American Association for University Women (AAUW) [13] summarizes the importance of growth mindsets to female students’ success in higher education.) For general student populations, however, the same study finds “only a very weak relationship between mind-sets and academic achievement” and “only a very small effect of mind-set interventions on academic achievement.” However, Carol Dweck’s response [9] points out that the effect sizes reported in [21] for those general populations are large when the right comparisons are made, and that growth mindset interventions are more cost effective to implement compared to other interventions with similar effect sizes (e.g., reducing class size).

## 2.1. Summary

Taking these research findings as a whole, what emerges are the following recommendations. An equitable, meaningful, and effective grading system should:

- (i) Be based on frequent, low-stakes, short assessments
- (ii) Favor formative assessments over summative ones
- (iii) Clearly articulate what students will be assessed on
- (iv) Afford students multiple opportunities to demonstrate mastery of those objectives

- (v) Base students' final grade on their mastery of those objectives

In the next section, I describe how I synthesized these takeaways from the research into Second Chance Grading.

### 3. SECOND CHANCE GRADING

#### 3.1. The System – Foundations

The core of Second Chance Grading is illustrated in [Figure 1](#). Let me explain the Figure by simultaneously illustrating the algorithm I use to convert a course's grading system into Second Chance Grading.

- *Step 1: Divide the course content into 20 topics.*

The exact number of topics is irrelevant (it will soon become apparent why 20 works well for this system). Importantly, by “content” I mean “what you want students to learn.” For example, my Calculus II course included the topics “Volumes of solids of revolution” and “Geometric series, with applications.”

- *Step 2: Schedule 10 short quizzes throughout the course, each testing 2 new topics.*

This amounts to roughly one quiz a week in a typical college semester. I allot students 20 minutes for each quiz in my 70-minute classes, with each topic worth 10 points.

- *Step 3: Schedule two “second chance exams.”*

Give these “exams” during the same days as Quiz 4 and Quiz 8. They should consist of alternate versions of topics tested since the beginning of the semester or the previous exam, respectively. Make each topic’s grade the maximum of the new topic score and the old topic score. This rewards students for doing better on a topic the second time around.

- *Step 4: Schedule one “second chance final exam.”*

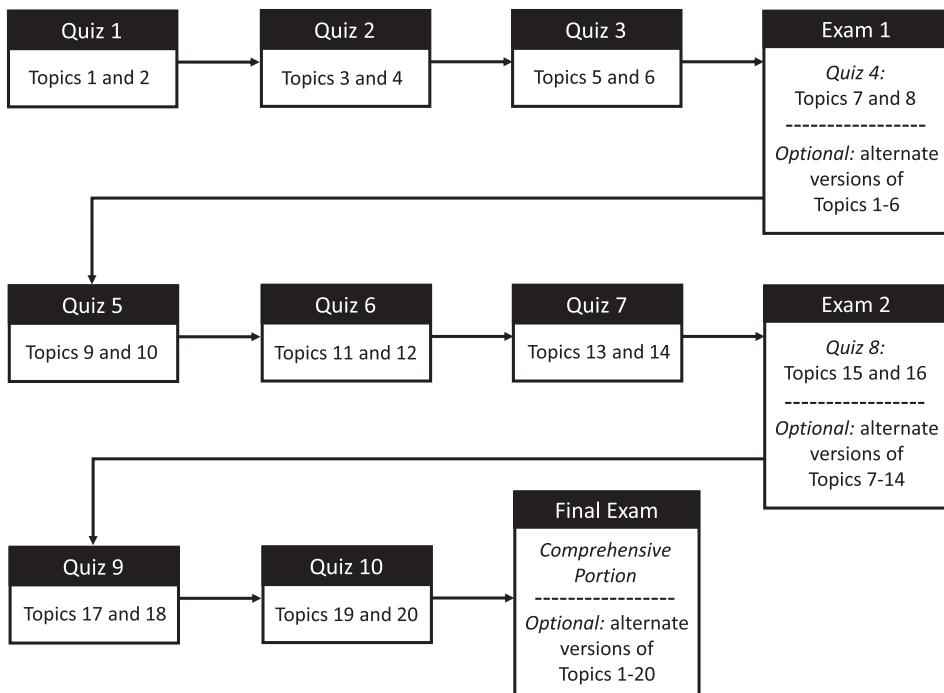
Write the final exam to consist of a required comprehensive portion – similar to a typical final exam – and an optional section containing alternate versions of topics tested since the course began. In my course, students are allotted 2.5 hours for the final exam; I design the comprehensive portion of the final exam to take roughly 1 hour. Grade the optional portion as before (maximum topic score).

- *Step 5: Compute the final grade.*

In my implementation, I assign 80% of the grade to the equally weighted quizzes and the remaining 20% to the comprehensive portion of the final exam.

#### 3.2. The System – Additional Supporting Structures

I have also built into my courses additional structures supporting the implementation of Second Chance Grading. Let me describe these now. For context, I teach on a Monday, Wednesday, Thursday schedule and each class lasts 70 minutes.



**Figure 1.** Assessment structure of the second chance grading system.

- (A) *Lesson Notes.* On Sundays I post “skeletal outlines” for the week onto our Learning Management System. These are documents containing the definitions, theorems, and statements of examples we will be discussing that week (with some brief commentary on them) as well as lesson agendas, practice problems, and information on additional resources such as reading from the textbook. During class the students and I fill in the proofs, calculations, and other relevant content not contained in the outlines.
- (B) *Homework.* I list suggested “practice problems” on the skeletal outlines but do not assign or collect homework. I have chosen this approach to homework for two reasons, one research-based and one equity-based. The first is that the research on the learning benefits of homework is mixed [15]. My approach attempts to retain the beneficial aspects of homework (e.g., another form of formative assessment) yet avoid the detrimental effects (e.g., anxiety related to homework deadlines). The second is that I have found homework scores to be highly correlated with how well students use their resources (office hours, tutoring, the right websites, etc.). But not all students have equal access to those resources. Some students need to work campus jobs and their work hours conflict with office hours. Other students may not come to office hours because they feel too intimidated to interact one-on-one with the professor. Yet other students might refrain from asking questions for fear of seeming incompetent, or worse, feel stereotype threat as a result of revealing their gaps in understanding.

Despite practice problems not being collected, I do make efforts to encourage students to do them. For example, I frequently mention results from the practice problems during class and also in my emails about quiz content (see below). I also sometimes leave out steps in a proof or calculation in the skeletal outlines and suggest students fill them in as part of the lesson's practice problems. Finally, I post solutions to practice problems on Saturdays.

- (C) *Quiz Design.* I typically create quizzes on Fridays, *after* having taught the week's content, and administer them on the following Wednesday. I strive to ensure that content tested on the quizzes:

- Assesses students' mastery of topics covered that week
- Connects directly to my course's learning objectives
- Spans various taxonomies of learning (e.g., Bloom's and Fink's; see [10]) and various cells in Hess' Cognitive Rigor Matrix [12]

I send a Quiz Guidance email after I create the quiz that communicates the topics tested on the quiz and the areas of emphasis.

- (D) *The Second Chance Exams.* I allow students to bring in a small note card into Exams 1 and 2. I advise them to include, at the very least, which topics they intend on re-attempting.

Finally, I explicitly discuss exam strategy with students. For example, I point out that on second chance days they *could* disregard the quiz portion and focus solely on re-attempting previously tested content. (I remind them that they will get a second chance on the quiz content on the final exam.) I also advise them to think about their problem-solving strategy. For example, some might benefit most from re-attempting topics they have the lowest scores on first; others from re-attempting topics they now understand very well first.

The structures and supports described in these last two subsections constitute the core of Second Chance Grading. I have left out certain additional details – like how I grade the quizzes – in the interest of preserving some freedom in the implementation of the system. But if you are interested in those additional details, I discuss them in the Appendix.

Let me now close this subsection by discussing how I believe Second Chance Grading realizes the original six objectives laid out in the Introduction (I will reference these as 1–6) and incorporates the five researched-based recommendations from [Section 2.1](#) (I will reference to these as i–v).

Second Chance Grading is built around frequent, short, and low-stakes quizzes (5–6, i). (My experience has been that students consider weekly quizzes to be “frequent” and low-stakes, given that each quiz is worth just 8% of their final grade.) The Quiz Guidance emails clearly articulate what students can expect to be tested on (iii) and because students' quiz scores can improve over time (1–2, 4, iv), the quizzes – and my conversations with students about them – are more formative than summative in nature (ii). Finally, since students' final grades are based mainly on their quiz performance, which in turn depends on their mastery of the content,

their final grades are more connected to mastery than they were in my original high-stakes grading system (3, v).

Now that you have a detailed understanding of Second Chance Grading, let me discuss my experience using the system since Summer 2017.

#### **4. REFLECTIONS ON SECOND CHANCE GRADING**

A total of 149 students (with only a few exceptions, unique students) completed the 10 courses I have used the system in as of August 2019. Those 10 courses span 7 subjects: Calculus I, Calculus II, Differential Equations, Mathematical Methods for the Sciences, Linear Algebra, and an upper-level proofs-based Fourier Analysis course. Of those 149, 139 submitted their end-of-semester evaluations. While I have yet to conduct a controlled study of Second Chance Grading's effectiveness, those evaluations suggest that the system is working as designed. Specifically, of those 139 evaluations:

- 82 (59%) mentioned Second Chance Grading and 79 of the 82 (96%) had only positive things to say about the system. One student summarized it well: “I enjoyed the focus on learning, and not on perfection.”
- 51 of the 82 (62%) wrote substantive comments about Second Chance Grading (the remainder gave only one-sentence praise for the system).
- 21 of the 51 (41%) mentioned that Second Chance Grading decreased their stress or anxiety about grades, learning, and mathematics. As one student wrote: “Second chance grading alleviated the pressure to cram material. If I had trouble understanding a concept initially, I was awarded more time for mastery.” Another student, putting it more succinctly, said: “It was the least stressful math course I’ve taken while also the course where I learned the most.”
- 28 of the 51 (55%) mentioned that the system improved their learning. As one student wrote: “Because we were able to retest topics, I felt like I could actually learn from my mistakes and show that I was improving throughout the semester.” Another student noted that she “felt as though the weekly quizzes helped me summarize my learning each week in an effective way.”
- 2 of the 51 (4%) mentioned that they particularly appreciated the clear standards the Quiz Guidance emails provided. The most insightful comment: “In most math classes, professors will not say what they will ask on the test. This makes students feel like there is something hidden that will not be revealed unless the exam booklet is opened. By telling us what he will ask about, professor Fernandez removes the hierarchical prof-student structure that is evident in most classes. Every time I sat for studying, I knew what was important and that made me really grasp the storyline of the class. I am such a big fan of his system.”

This sampling of student reflections on Second Chance Grading reinforce the results of my own qualitative analysis of the biggest impacts of the system. Let me divide

these impacts into two categories: impacts on students, and impacts on myself as their instructor.

#### **4.1. Impacts on Students**

The system's most noticeable impact has been the great *reduction* in students' anxiety about testing and grading despite the *increase* in the number of assessments and their frequency. Moreover, students now view the assessments I give them as more authentic measures of their learning, a process they now recognize is dynamic and takes time.

I have also noted students using more growth mindset language and reasoning, both in conversations with them and overhearing conversations between them. Phrases like "I didn't get it at the time but I'm making progress on it now" and its variants are more common now.

Finally, I have also noted an increase in students' self-confidence. Separating content by topic has helped students realize that they *are* good at *many* things, even if they feel like overall they are struggling. Moreover, the confidence boost a student receives when she achieves a significantly higher score the second time around is palpable.

#### **4.2. Impacts on the Instructor**

Second Chance Grading has also led to a few important day-to-day changes in my interactions with my students. Gone are the days when students would show up hours before the homework is due frantically asking for help in the hopes of turning it in on time. And gone are the timeless "will this be on the test?" questions, as well as the overall focus on tests in the class. My interactions and conversations with my students these days are much more about *learning* and much less about their *performance* on assessments and in the course in general.

My office hours have also changed for the better. Students now come in and ask me deeper questions about the content. They do this, I think, because under Second Chance Grading they need to understand the content *better than before* in order for their grade to improve. And an unforeseen added benefit: I now feel free-er to be more honest in my grading. I routinely ignored small errors in students' solutions to exam questions under my old high-stakes grading system, in part because every point lost would lower their maximum possible grade. By contrast, in Second Chance Grading I feel *obliged* to point out any and all areas for improvement. How else can I expect them to master the content?

In addition to being well-received by students, Second Chance Grading has also been well-received by the faculty I have trained to use the system. Their experiences echo what I have discussed herein: lower student anxiety, increased learning, minimal upkeep of the system, and increased student satisfaction with the course.

## 5. CONCLUSION

Second Chance Grading provides an easy way to leverage and implement the five takeaways from the research literature on grading, growth mindsets, and the general science of learning listed in [Section 2](#). Implementing the system is fairly straightforward (c.f., [Section 3.1](#)), though may require some modification for humanities courses and some social sciences courses. (This is part of the reason I wanted to discuss the research behind Second Chance Grading first – many of those findings are more broadly applicable.) The additional structures described in [Section 3.2](#) that support the system could also be tweaked to suit your purposes. I also recommend reading the Appendix; it contains additional details about other choices I made (e.g., how I grade each quiz).

What I have found most surprising about Second Chance Grading is how closely the results match the predictions stemming from the research. As illustrated by the student feedback discussed in [Section 4](#), and through my own experiences with my students, nearly all predictions of the research discussed in [Section 2](#) have materialized in my courses – students report lower anxiety levels, increased retention and learning, and appreciate the system's emphasis on transparency and explicit communication.

Despite these successes, Second Chance Grading is not free from issues. For one, Second Chance Grading is not for everyone – 3 of the 139 students (roughly 2%) whose evaluations were discussed in the previous section reported not liking Second Chance Grading because of its focus on short quizzes. These 3 students were accustomed to having much more time than was afforded to complete quizzes (the students did not have a learning accommodation that called for extended time on assessments). I discuss in the F.A.Q. in the Appendix why I have resisted allowing students more time on the assessments. Another potential issue is the fact that 67 of the 139 students filling out student evaluations did not explicitly comment on Second Chance Grading. It may be the case that these students thought positively about the system but did not comment on it, or that they thought negatively about it but did not comment on it. Finally, I find that converting a course into Second Chance Grading does produce a net (small) gain in work. I have to generate alternate versions of the quizzes and spend more time grading than before. At the same time, I no longer hold exam review sessions (the exception is for the final exam), since the second chance exams are not true exams. I am more than happy to trade this small increase in work, however, for the positive effects Second Chance Grading has had on my students. And given how easy the system is to implement, manage, and tweak, I encourage you to experiment with Second Chance Grading (and let me know how it goes).

## ACKNOWLEDGEMENTS

I wish to thank all of the students who have given me detailed feedback about Second Chance Grading, as well as my colleagues who have supported me in my implementation of the system.

Your collective comments have been immensely valuable.

## APPENDIX

This appendix contains two subsections: an F.A.Q. on Second Chance Grading and samples of a Quiz Guidance email, one of the quizzes, and one of the second chance assessments (these last three are for the linear algebra course I taught in Spring 2019).

### A.1. Frequently Asked Questions About Second Chance Grading

Below I give one set of possible answers to a few frequently asked questions regarding Second Chance Grading. My answers are driven by my goals, experiences, and perspectives, but I also include my reasoning in an attempt to help you think about how you might address these questions yourself were you to implement Second Chance Grading.

- (1) *How can you ask about content requiring higher-order thinking skills if you only allot 20 minutes for each quiz?*

As the instructor, you control what content gets tested in each of the 20 topics. If, for example, one of your course's learning objectives is to develop a higher-order cognitive skill in students (e.g., creating mathematical models of specific phenomena), you could devote one of the 20 topics to testing that skill. (Make sure to explicitly teach students the topic beforehand!) Mathematics being mathematics, some topics end up naturally being "capstone topics," requiring students to synthesize the knowledge they have learned over multiple lessons. These topics naturally emphasize higher-order cognitive skills.

- (2) *Do you grade the quizzes and exams using the X, P, G, M scale in typical mastery grading schemes?*

No. This is one way in which Second Chance Grading departs from most mastery grading systems. For me, the X, P, G, M buckets are too broad. Students in the G bucket, for example, are likely at different "G levels," in that some are just on the brink of achieving the M level while others barely got into the G level to begin with. In addition, I can imagine a G-level student reattempting work that I judge better than her previous work yet not good enough to get her into the M level. For that student, G would remain G. This promotes an anti-growth mindset, in my view.

For these and related reasons, I still grade students on a 0%–100% scale for each topic on each quiz. Because each topic consists of 10 points (I often mark off half points), it is very easy to grade students' work. Legitimate criticisms of percentage-based systems include the fact that they effectively focus on completion (as in "you got 90% of the possible points"). While this may be true in the abstract, at least in my courses, a student cannot earn a 90% on a topic without having demonstrated a deep understanding of the content and on multiple cognitive levels (again, because I structure my assessments with Bloom, Fink, and Hess in mind). The percentage system also makes numerically clear how much of the content tested was mastered (where "mastered" is defined as "answered every question correctly") and better differentiates among students' scores.

- (3) *How do you keep track of students' performance?*

I maintain an online spreadsheet with students' scores on each topic. I color yellow any topics whose score is less than 80% and suggest to students they consider reattempting those topics. When I grade the second chance exams and students score better on previously-tested topics, many previously yellow cells now revert to white. This is learning, visualized. The "heat map" the spreadsheet creates also helps me determine which topics were particularly challenging for the class as a whole, and helps me communicate students' individual progress to them.

- (4) *Has Second Chance Grading increased your average class grade?*

Yes, but not significantly – class averages have risen by about 1/3 of a letter grade (so, for example, B to B+).

- (5) *Do students ever run out of time to re-attempt topics during the second chance exams?*

This has only happened to a handful of students. I credit three things for this. First, my frequent encouragement to students to get things right the first time, precisely because they do not want to find themselves in this situation (of having too many topics to re-attempt). Second, the arithmetic of the time allotted on the second chance exams and the quizzes. Exams are 70 minutes long, quizzes 20 minutes long. Since each exam affords students the time to re-attempt the topics on the previous 3 quizzes, students wishing to re-attempt all 3 quizzes' topics should spend about 60 of the 70 minutes allotted for the exam (leaving 10 minutes for the quiz portion of the exam). Third, the course structure itself. Having a quiz every week promotes retention of content. This, I suspect, gives students a performance boost when they take the quiz, resulting in fewer topics needing to be reattempted.

- (6) *Why not make the quizzes take-home? That would allow everyone more time.*

I cannot be sure that students will not cheat. And since Second Chance Grading aims to be equitable, this in part means ensuring that assessments measure only individual learning, not collective learning (“collective” as in “individual plus some form of help”).

- (7) *Do students try less hard the first time they attempt a topic because they know they can re-attempt the topic later?*

In general, no. As I articulated earlier, I stress to students that they get things right the first time around, which encourages them to put forth their best effort on every quiz. There are instances, however, when students have deliberately not tried their hardest precisely because they knew they would get additional opportunities to raise their scores. These instances include students falling ill, feeling overwhelmed with other work or life, and other reasonable reasons. That Second Chance Grading affords students this flexibility is, I think, a very positive thing.

- (8) *Why not offer students unlimited and/or on-demand re-attempts?*

Two reasons: both of these options would be incredibly time consuming, and both de-incentivize students to get things right the first time.

- (9) *Why not have second chance exams include all previously tested content?*

Including all previously tested content on each second chance exam would weaken student's motivation to get things right the first time. In addition, every exam would have to be longer (to give students a realistic amount of per-topic time). Finally, in such a system the earliest topics would be associated with the greatest number of re-attempts, and the latest with the fewest.

## A.2. Samples

### A.2.1. Quiz Guidance

Here is the Quiz Guidance email I sent to my linear algebra students ahead of Quiz 6 in that class:

“The quiz will cover the following two topics.

Topic 10: Dimension of Vector Spaces. I will ask you a mix of computational and conceptual questions about dimension. For the computational part, expect questions similar to the first few problems in the Practice Problems for Video 15 document. (If I include a question similar to 2.20(b) or 2.20(c) on the quiz, I will simplify it to make it faster for you to answer.) For the conceptual part, they will be similar to questions 2.32 and 2.34 on the document, and the suggested questions on the Practice Problems for Video 16 document. (I may also, as I often do, ask about definitions and theorems related to dimension.)

Topic 11: Vector Spaces and Linear Systems. I will similarly ask a mix of computational and conceptual questions here. Let me exclude problem 3.41 from the Practice Problems for Video 17 sheet though. I suggest working through the other exercises in that document, as well as reviewing the examples we did today in class.”

### A.2.2. Quiz and Second Chance Assessment

Quiz 6 from that same linear algebra class, as well as the second chance day assessment that contained alternate problems related to the Quiz 6 topics, can be accessed online as supplemental material.

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## BIOGRAPHICAL SKETCH

Oscar E. Fernandez earned his Ph.D. in Applied and Interdisciplinary Mathematics from the University of Michigan, Ann Arbor, in 2009. While there he became interested in pedagogy and the science of learning, spurred on by the University's comprehensive training of its Graduate Student Instructors in active learning and inquiry-based learning. After Michigan, Fernandez joined the faculty at Wellesley College – a liberal arts college for women in Wellesley, MA – where he is now an associate professor of mathematics. In 2017 he was appointed Faculty Director of the college's Pforzheimer Learning and Teaching Center. In that role, he supports faculty at the College as they explore new instructional strategies and new mechanisms for assessment, and coordinates New Faculty Orientation. He regularly organizes workshops on pedagogical topics of interest to the faculty and helps manage funding sources intended to encourage innovative teaching.