Application and Analysis of Specifications Grading in an Upper-Division Applied Mathematics Course

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What Does a "C" in (Insert Math Class Here) Mean?

- Most grading systems in mathematics assign *point values* to various levels of student work based on rubrics with various degrees of rigor.
- These point values are then weighted to determine a student's course grade.
- This is problematic in any setting, but in mathematics its implications can be tragic. For example, if a student earns 95 % (an A) on 5 independent topics that are needed to solve a problem in the future (assuming perfect retention), the student is more likely a

$$0.95^5 = 0.774$$

  a 77 % (a C) student.
- Additionally, *students that earn an 80 % in a course can do so by complete mastery of 80 % of the topics, or 80 % mastery (whatever that means) on all the topics, as well as everything in between*.
- This is working against my approach as a mathematician and an educator (as documented in Talbert 2017).

Specifications Grading

- *Specifications grading* (Nilson 2015) is a system that, instead of using points to assess student work, grades on a two-level rubric
- This two-level rubric can be a variation of "Pass/No Pass", but generally *relies on the professor's professional opinion of what is an isn't acceptable work*. All items are able to be *revised until the semester concludes*, with the same threshold applied each reassessment.
- Course grades are then assigned via a backward-design-constructed set of tiers ("bundles") for successfully-completed problems/tasks constitute earning a particular grade.

A bundle: all questions below, and questions 5, 14, 15 and 18 and 97.5% on quizzes

AB bundle: all questions below, ≥ 2 from questions 5, 14, 15 and 18 and 92.5% on quizzes

B bundle: all questions below, and questions 3, 4, 10, 11, 13 and 17 and 87.5% on quizzes

BC bundle: all questions below, ≥ 3 from questions 3, 4, 10, 11, 13 and 17 and 82.5% on quizzes

C bundle: all questions below, and questions 1, 7, 8, 9, 12 and 16 and 75% on quizzes

D bundle: questions 2 and 6 and 65% on quizzes

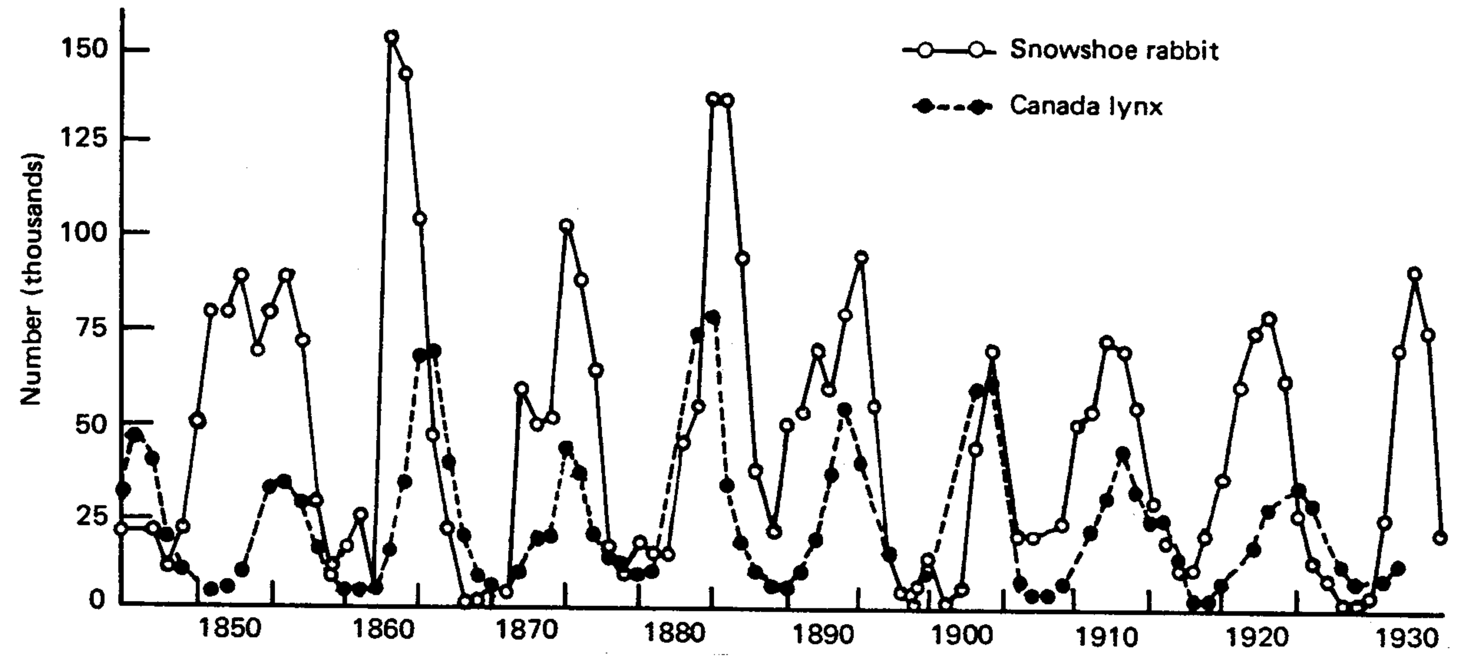
Note: to obtain a D or better in this course requires the successful completion of the group projects and three Mathematical Community activities.

MTH 353 (Differential Equations) Course Overview

Course Description: *A first course on the modern study of differential equations including mathematical modeling and numerical solutions. Topics include the formulation of differential equations and interpretation of solutions, fundamental existence and uniqueness theory, first-order linear and separable equations, a dynamical systems approach to linear and nonlinear first order systems, numerical methods and qualitative analysis, and Laplace transforms. Applications and modeling of real world phenomena will be integrated throughout. Prerequisite: MTH 309 (Linear Algebra) and MTH 310 (Calculus III).*

Learning Objectives:

- Cultivate an understanding of the process of solving a problem by reviewing the important information, developing a plausible mathematical model, obtaining solutions, and evaluating the results.
- Understand the basic theory, numerical techniques, and solution methods to elementary differential equations.
- Explain and apply the basic concepts of calculus including the various forms of derivatives and integrals of continuous functions, their interconnections, and their uses in analyzing and solving problems from other disciplines of science.
- Most importantly, be able to articulate mathematical ideas verbally and in writing, using appropriate terminology.



References

Nilson, L. B. (2015) Specifications Grading: Restoring Rigor, Motivating Students and Saving Faculty Time. Stylus Publishing, Virginia.

Talbert, R (2016) Specifications Grading: We May Have a Winner. http://rtalbert.org/specs-grading-iteration-winner/

Methods

- I taught MTH 353 in the spring of 2017 and the fall of 2017.
- During the spring semester I assigned grades as if it were a regular course, but also graded their exams as if I had the specs grading system in place.
- I used specs grading during the fall of 2018.

Results

Problem Type	Met Specifications in Spring	Met Specifications in Fall
First-Order Linear	56.5%	57.9%
Separable Equations	78.2%	84.2%
Mixing	30.4%	52.9%
Linearization about Equilibria	13.0%	5.2%
Existence and Uniqueness	8.7%	52.6%
Two Solutions	82.6%	88.2%
Second-Order to Systems	21.7%	35.3%
Second-Order Solutions	47.8%	70.5%
Real, Distinct Eigenvalues	87.0%	88.2%
Real, Repeated Eigenvalues	87.0%	41.2%
Complex Eigenvalues	60.9%	29.4%
Nonlinear Analysis	60.9%	35.3%
Nullcline Analysis	43.4%	29.4%
Method of Undetermined Coefficients 1	73.9%	82.4%
Method of Undetermined Coefficients 2	95.7%	76.5%
Laplace Definition	91.3%	70.6%
Laplace Set Up	69.6%	76.5%
Laplace Solution	65.2%	41.2%
Group Project	20.0%	67.0%
Individual Project	34.8%	11.8%

Observations and Conclusions

- *None of the differences in student achievement were statistically significant*, due in large part to small sample sizes ($n_1 = 23$, $n_2 = 17$).
- As the semester went on, students *found the revision opportunities liberating* (gleaned both from personal conversations from students and through the temporal trends in the data).
- Future work involves implementing this in all of my classes (it's currently a part of my MTH 175, 207 and 208 courses as well), and *finding a revision structure that splits the difference between being too liberal and too restrictive*.

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