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Mastery Learning in Calculus I Affects Student Learning, Grade Improvement, and Professor Exhaustion

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Introduction

"My students *really learn* calculus," declared a mathematician. "An educationist responded, 'Nothing short of mastery of a subject should be tolerated at the university' (Dolch, 1934, p. 121). What do you do when students receive low exam scores?"

Their ensuing discussion prompted the formation of a research partnership consisting of two semesters of mastery learning in Calculus I, following a previous semester of traditional teaching. Their research culminated with the mathematician, although 'near death' exhausted, happily and fully committed to teaching Calculus I with mastery learning.

The term "mastery learning" as coined by Bloom (1968, 1971) is nearly five decades old. Bloom (1971) posited that if students were given time for mastery of the subject and quality instruction, then the typical normal curve of student achievement based on standard pacing and instruction would shift toward higher student achievement by allowing for individual differences in learning to be addressed with extra teaching and learning time and extra effort by both the instructor and the student (see Block, 1971).

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Abstract

Three Calculus I courses were taught under conditions of traditional teaching, 2/3 mastery, or full mastery to test four hypotheses. Under conditions of mastery learning on exams, students should *attain* appropriate higher-level mathematical concepts, *achieve more learning* of higher-level mathematical concepts, *learn* higher-level mathematical concepts *more quickly*, and *evaluate mastery learning favorably*. Support for all hypotheses occurred only in the 2/3 mastery condition. A shift toward higher grades was attributed to grade improvement, *not* grade inflation, as determined by six mathematicians with blind review of final exam items. Final exams in mastery learning courses were significantly more difficult. We discuss effects of mastery learning on student learning, grades, and the professor.

Methods

A case study design used a mixed methods approach to compare grades, exam scores, and student reflections under conditions of 2/3 mastery, full mastery learning, and traditional instruction. In the mastery conditions, students could correct their missed points on exams for half credit added back to their original score.

	Spring 2012	Fall 2012	Spring 2013
	Traditional	2/3 Mastery	Full Mastery
Week 1			
Week 2			
Week 3			
Week 4	Exam 150 pts		
Week 5		Exam 200 pts	Exam 200 pts
Week 6		Mastery	Mastery
Week 7	Exam 150 pts	Mastery	Mastery
Week 8			
Week 9			
Week 10	Exam 150 pts	Exam 200 pts	Exam 200 pts
Week 11		Mastery	Mastery
Week 12		Mastery	Mastery
Week 13	Exam 150 pts		Exam 100 pts
Week 14			Mastery
Assignments	50 points	200 points	200 points
Final Exam	350 points	400 points	300 points

Figure 1. Traditional and mastery learning research design with exams shown across three semesters of Calculus I.

Six mathematicians under conditions of blind review rated appropriateness (yes / no) and difficulty (0 = easy; 10 = difficult) of randomly arranged items from the traditional and mastery learning final exams.

Appropriate for Calculus I?	
YES	NO

Results

Course grades across three semesters of Calculus I.

S12 Traditional (38 students)	F12 Mastery (2/3) (34 students)	S13 Mastery (100%) (35 students)
A = 8	A = 13	A = 11
B = 14 (22 A's & B's)	B = 9 (22 A's & B's)	B = 6 (17 A's & B's)
C = 8	C = 3	C = 8
D = 1 (9 C's & D's)	D = 2 (5 C's & D's)	D = 0 (8 C's & D's)
F = 5	F = 3	F = 7
W = 2 (7 F's & W's)	W = 4 (7 F's & W's)	W = 3 (10 F's & W's)

Mathematicians' ratings of two derivatives on Calculus I final exams.

Final Exam Items	Semester	Item Difficulty (SD)
Find $f'(x)$ where $f(x) = e^{2x} - 3x$	S12 & F12	3.8 (*SD* = 1.83)
Find $f'(x)$ where $f(x) = \text{Ln}(\cos^2(3x^2 + 5x))$	F12	7.3 (*SD* = 1.37)

Note. Standard deviation is abbreviated as SD and placed within parentheses. S12 and F12 refer to Spring 2012 and Fall 2012.

All final exam items were rated as appropriate for Calculus 1. Moreover, the six mathematicians rated items associated with mastery learning as more difficult than items associated with traditional learning ($t(5) = 3.123$, $p = 0.026$*).

Student comments revealed eight themes about mastery learning.

1. Benefits of revisiting course material.
2. Extra points.
3. Enhanced problem-solving skills.
4. Prevention of missed opportunities.
5. Working additional similar problems.
6. Requesting additional work.
7. Satisfaction with learning.
8. Preference for mastery learning over conventional grading.

Concluding Remarks

We happily report a professor's enthusiasm and energy – to the point of exhaustion – for use of mastery learning in teaching Calculus I. Our research design involved reducing the number of exams to provide ample time for mastery learning following each exam. The professor perceived these mastery learning periods as extremely important and fruitful. "Students who normally were uninvolved suddenly became engaged". We note with emphasis the positive and quite perceptive evaluations students provided concerning their experience with a regimen of mastery learning. "*I have a much better understanding of the material than in classes where I just took the test and never looked at it again."* Importantly, 100% of students rated mastery learning favorably.

The Calculus I professor reflected on the consistency of final exam scores and course grades under the mastery regimen relative to traditional learning as "MOSTLY DUE TO having increased expectations regarding student learning and, hence, making the mastery learning exams harder" (personal communication, July 22, 2013). Nevertheless, students achieved more grades of A under conditions of mastery.

Although mastery learning comes with a high cost of time required for iterative grading and feedback, we posit that mastery learning on exams is helpful to learner-centered teaching and improved grades reflective of increased student learning.

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