Implementing Standards Based Grading Across Lower Level Mathematics Courses

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Institutions and Courses

Courses:

- Precalculus
- Differential Equations
- Linear Algebra
- Differential Equations
- Elementary Statistics
- Calculus 1

Spring Hill College:

- Jesuit, Private, Liberal arts
- Around 1,200 students
- Class sizes: 25

Florida Southern College:

- Private, Liberal arts
- Around 2,400 students
- Class sizes: 13, 25

A Critique of Averages

Do these averages properly describe the abilities of the student?

	Exam 1	Exam 2	Exam 3	Average
Student A	75	73	77	75
Student B	100	30	95	75
Student C	50	80	95	75
Student D	100	65	60	75

Which parts of the course did the student complete successfully?

- Averages lose information
- A system using pionts and averages is broken

Criteria for Evaluating Grading Systems

1. Uphold high academic standards

$$\downarrow \text{rigor} \quad \Longrightarrow \quad \uparrow \text{student satisfaction}$$

2. Reflect SLO's

Which parts of the course?
Which learning outcomes exceptionally well or not at all?

3. Motivate students to learn (vs. performance orientation)

points-based system $\Longrightarrow$ turns education into a game

4. Motivate students to excel

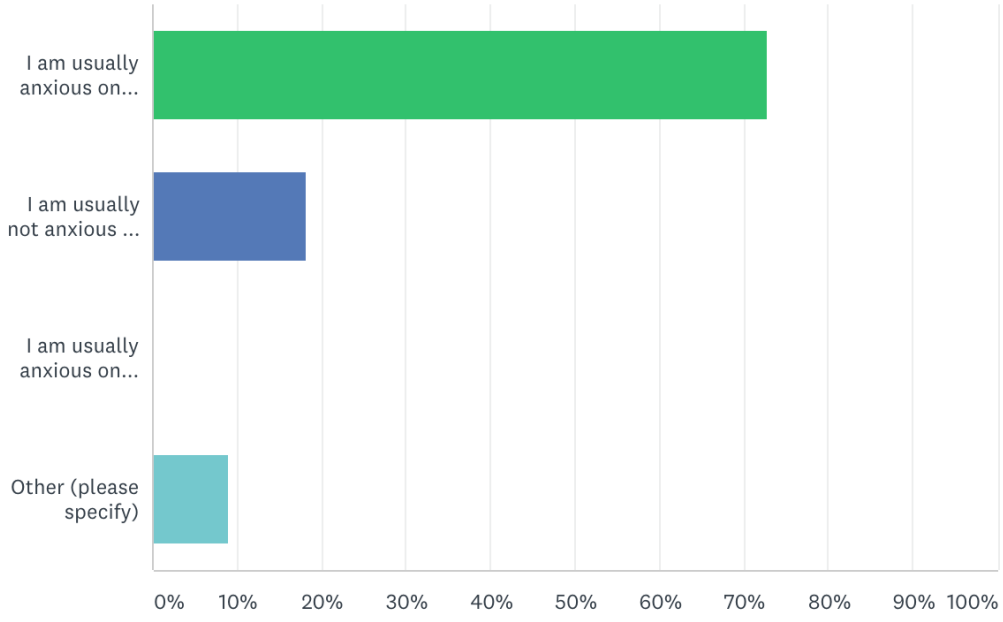
built-in incentives to demand strong performances to earn credit

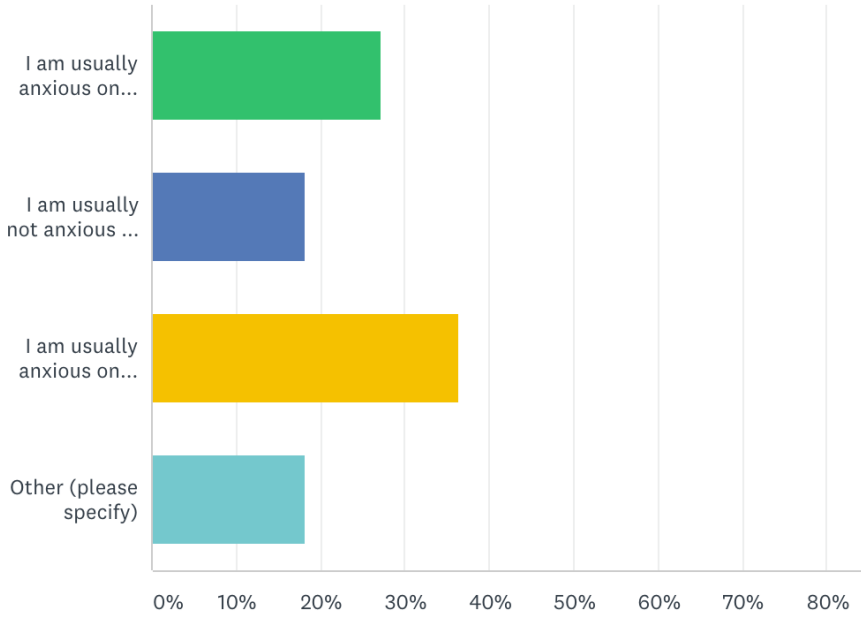
5. Reduce stress
6. Make students feel responsible for their learning (earned vs. given)

Stressful Assesments?

Evidence for stress: American College Health Association (2013)

51% indicated “overwhelming anxiety” (15% diagnosed)





Course Design by Learning Outcomes (Calculus 1)

Course is split into separate standards grouped into Big Questions.

- How can approximations lead to exact answers? The idea of limits.
- How do we calculate instantaneous rate of change?
- What are some important applications of derivatives?
- How do we compute area? The meaning of area.

Each module contains individual learning outcomes.

Module L: How can approximations lead to exact answers? The idea of limits.

☐ ☐ **L1: Difference Quotient.** Compute a difference quotient for a given function and describe the meaning of a difference quotient.

☐ ☐ **L2: Approaching a point.** Fill in a table of values to guess the value of a limit at a point or the instantaneous rate of change at a point.

☐ ☐ **L3: Definitions and Meaning.** Recite the definition of continuity at a point, describe the types of discontinuities, the ways a limit may not exist and the meaning of limit notation.

☐ ☐ **L4: Graphical limits.** Determine limits of a function and where it is continuous or differentiable given its graph.

☐ ☐ **L5: Algebraic limits.** Compute a limit at a point using algebraic techniques.

☐ ☐ **L6: Examples.** Sketch an example graph that has given limit values or continuity restrictions.

Using the Calendar

Monday	Tuesday	Wednesday	Thursday	Friday
17th	18th **9** Chapter 3 (3.1-3.3) Chapter 9 (9.1-9.2) **FO2, O3**	19th	20th **10** Chapter 9 (9.1-9.2) **FP1, P1 (3.1-3.3)**	21st
24th	25th **11** Section 7.1 Project #1 due **S1, U1 (9.1)**	26th	27th **12** Section 7.1 **O2, U2 (9.2)**	28th

Using a Binary Rubric

Problems are graded using a binary rubric:

Not Yet Mastered or Mastered

Each problem is given one of 5 *Star Wars* marks:

Mastered

- Jedi: completely correct
- Yoda: perfect on the first try (when applicable)

Not Yet Mastered

- Droid: requires major revision/incomplete
- Padawan: demonstrates some understanding but revisions are needed
- *: needs clarification/minor correction (can be replaced with Jedi)

Grade Bundles (Calculus 1)

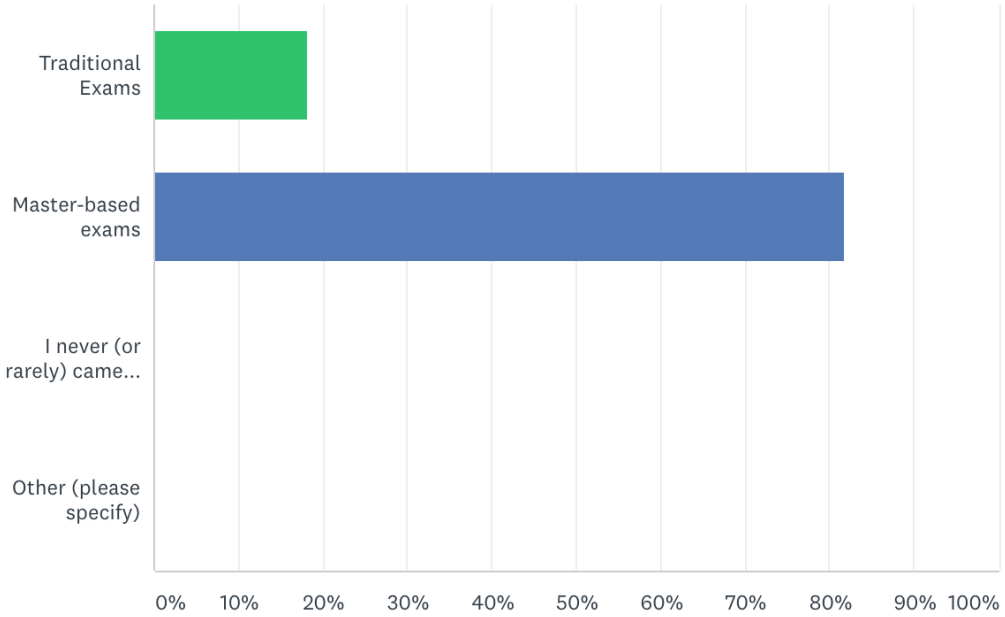
Course grade	D	C	B	A
Standards mastered once	☐ ☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐ ☐
Standards mastered twice	☐ ☐ ☐ ☐	☐ ☐ ☐ ☐	☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐ ☐
POGILs Completed	☐ ☐	☐ ☐	☐ ☐	☐ ☐
WebAssign Score	☐60%	☐70%	☐80%	☐90%
Participation Score	☐60%	☐70%	☐80%	☐90%

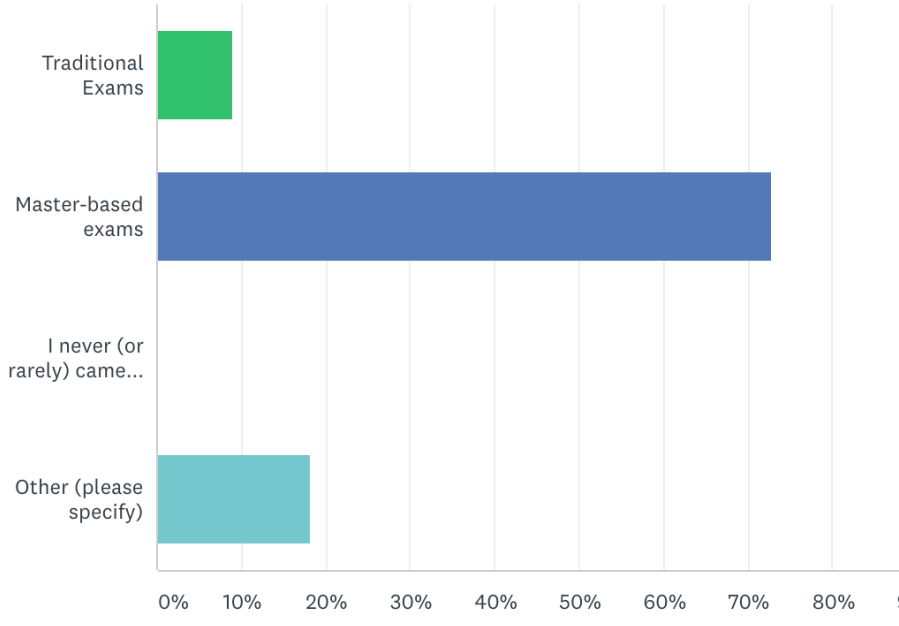
Grade Bundles (Linear Algebra)

Course grade	D	C	B	A
C standards mastered	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐	☐ ☐	☐ ☐
C standards continually mastered	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐ ☐	☐ ☐	☐ ☐
S standards mastered		☐ ☐	☐ ☐	☐ ☐
Participation Score	☐50%	☐70%	☐80%	☐90%
Homework Reports	☐ ☐ ☐ ☐	☐ ☐	☐ ☐	☐ ☐

Advantages

- several chances to display mastery
- see which parts of the course deserve more attention
- students learn from their mistakes
- students became more aware of simple mistakes
- writing improved
- students attended office hours





An Example from Differential Equations

S2: Determine all IC's for which a given IVP has a unique solution.

Example: DE: $(y - x)y' = y + x$, IC: (a, b)

Step 1: First write $y' = \frac{y+x}{y-x}$

Step 2: The function $\frac{y+x}{y-x}$ is continuous when $y - x \neq 0$.

Step 3: The function $\frac{(1)(y-x)-(1)(y+x)}{(y-x)^2} = \frac{-2x}{(y-x)^2}$ is continuous when $y - x \neq 0$.

Step 4: The IVP has a unique solution for any IC (a, b) for which $a \neq b$.

An Example from Differential Equations

S2: For a given initial value problem, determine all initial conditions for which the system will have a unique solution.

1. Determine the largest region in the xy-plane for which the differential equation would have a unique solution whose graph passess through the point (a, b).

$$\begin{cases} (\sqrt{y} - 1)y' = x \\ y(a) = b \end{cases}$$

$y^{\frac{1}{2}} = \frac{1}{2} y^{\frac{-3}{2}}$

$f_y(x) = \sqrt{y} - 1 \, dy$

$= \frac{1}{2} y^{\frac{3}{2}}$

the function x is cont. everywhere

$f_y(x) = (\sqrt{y} - 1) y'$

D

Attempt 2

$$y' = \frac{y^2}{x^2+y^2} \quad \leftarrow \text{can't} = 0$$

$$f_y = \frac{2y(x^2+y^2) - y^2(0+2y)}{(x^2+y^2)^2}$$

$$f_y = \frac{2y(x^2+y^2) - y^2(2y)}{(x^2+y^2)^2}$$

$$f_y = \frac{2yx^2+2y^3-2y^3}{(x^2+y^2)^2}$$

$$f_y = \frac{2yx^2}{(x^2+y^2)^2} \quad \leftarrow \text{can't} = 0$$

$(x^2+y^2)(x^2+y^2)$

$y^4+x^2y^2+x^2y^2+y^4$

~~x and y are continuous everywhere when $x^2+y^2>0$~~

this is continuous when $x^2+y^2>0$

Attempt 3

$(y-x)y' = y+x$

$y' = \frac{y+x}{y-x}$ → cannot equal zero

$f_y = \frac{(1+0)(y-x) - (y+x)(1-0)}{(y-x)^2}$

$f_y = \frac{(y-x)-(y+x)}{(y-x)^2}$

$f_y = \frac{y-x-y-x}{(y-x)^2}$

$f_y = \frac{-2x}{(y-x)^2}$ → cannot equal zero

∴ this is contin. when $y-x \neq 0$.

Hence by the theorem of IVP this has a unique solution for when $b-a \neq 0$.

Keeping a Gradebook

Sheet for attempts

Assessment	Q1	OH	OH	OH	Q2		OH		OH	Q3	OH						Exam 1								OH						Q4
Day Count	4	6	7		8	8		9		10	10	11					12								14						15
Standard	S1	S2	S1	S2	S2	C1	C2	C3	S1	S2	C3	C4	C1	C2	C3	C5	S2	C1	C2	C3	C4	C5	C6	S2	S4	C1	C4	C5	C6	S2	S4	C7
Student A	J			J		J	J					*/J						J		J		P	J									Y
Student B	J				P	J	D					*/J		J	P		*/J	J	J	J	P	*/J	P	P								P
Student C	Y	J				J	P				J	J		Y				J	*/J	J	J	P	P					J	*/J			P
Student D	D		J		D	D	D					D	P	J	*/J		P	P	*/J	D	P	P	D	P		J	J	J	P	J		D
Student F	J					J	P					J		Y	*/J		Y	*/J	J	J	*/J	P	J		J							Y

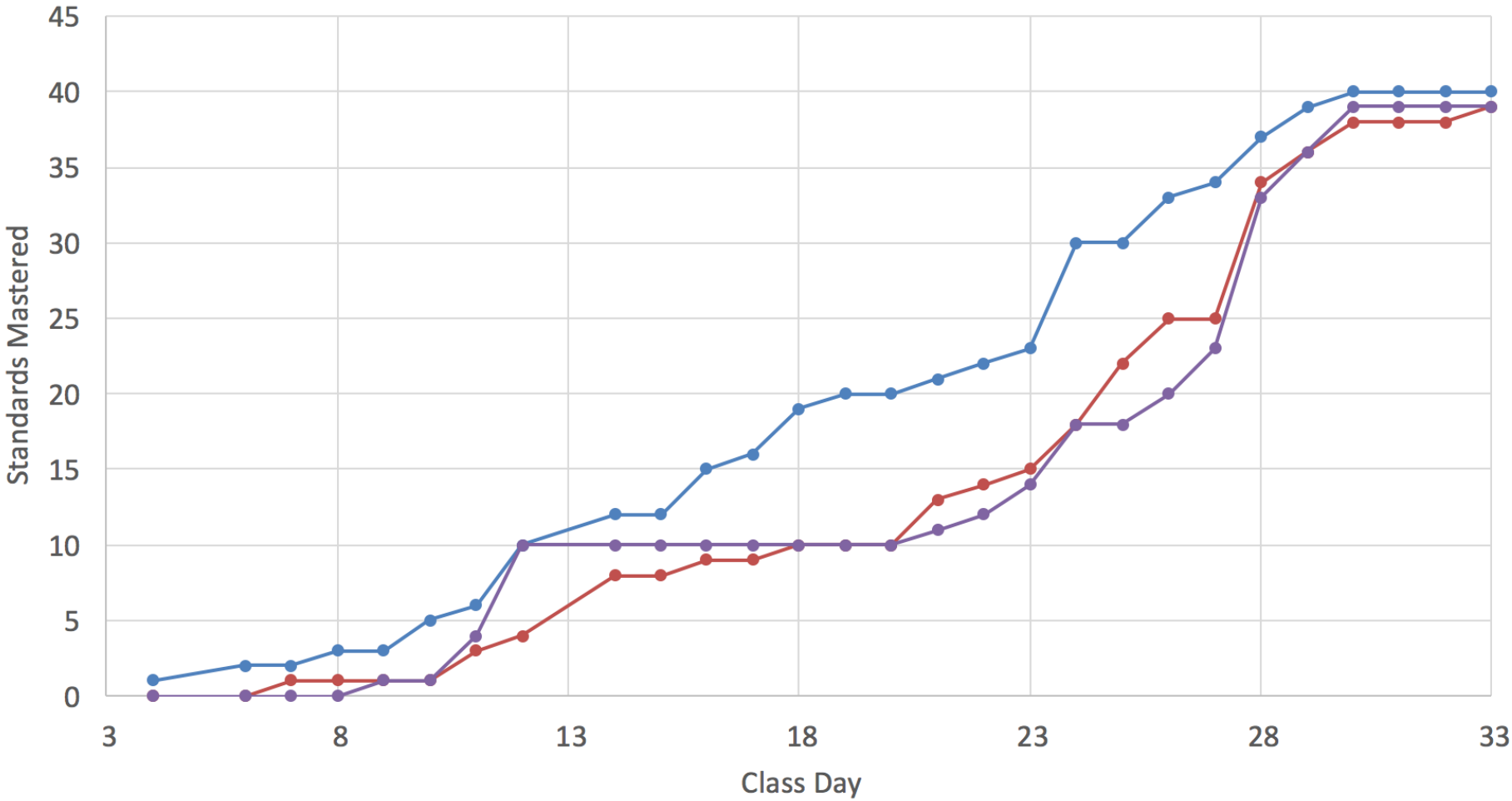
Y = Yoda (E), J = Jedi (M), P = Padowan (R), D = Droid (N)

Sheet for standards mastered

Standards	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	Total C	Total S	Total C+S
Student A	2	2	2	1	2	2	1	2	2	2	1	1	2	1	2	2	1		1	1	1	1	1	1	1	1			1	1	28	10	38
Student B	1	2	2			2	1	1	2	2	2	1		1	1	1			1	1	1	1	1		1	1	1	1	1		19	10	29
Student C	1	2	1	1	1	1	1	1	2						1	1			1	1	1	1			1		1		1	1	13	8	21
Student D	2	2	2	2	2	1	1	1	1	2	1	1				1			1	1	1	1	1	1			1	1	1		19	9	28
Student E	2	2	2	2		2		2	2	2	1		1		2	2			1	1	1	1			1	1			1	1	22	8	30
Student F	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1	1		1	1	1	1	1	1	1	1	1		1	1	29	11	40

SBG data promotes evidence-based teaching

Growth Charts



Additional Benefits

1) Partial Credit Misconception:

"If I were to get a question wrong then I would not attempt it again **because there would be no point**. But with the mastery exams, I have the opportunity to go back, look at what I did wrong and fix my mistakes."

2) Increases Retention:

"I'm pretty much made to stay after and answer questions and I have seen mass improvement since day one! Since I have to keep re-addressing the problem it **makes me remember it better**!"

3) Increases Confidence:

"My confidence in solving problems has greatly improved, not only in math but **across all subjects**."