Mastery Grading in Secondary Mathematics

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Overview

I tried Mastery Grading for the first time in BC Calculus I last semester and had a great experience. I am using the same grading method in BC I/II and MVC this semester.

I will not repeat any of the theory that Dr. Guskey presented. Instead, I will attempt to explain:

1. What Mastery Grading looks like in practice.
2. How I overcome various practical difficulties.
3. Why I think this system is better than the way I graded in the past.

The old grading system

My previous (traditional) grading system:

- Quizzes/tests: 60% of the course grade
- Classwork / homework: 20% of the course grade
- Cumulative final exam: 20% of the course grade

All assessments were points-based. We had a quiz about once every two weeks, with no retakes allowed. Grade penalties for work turned in late.

Things I didn't like about this grading system:

- Students were preoccupied with their grades, some developed test anxiety which was sometimes severe (panic attacks, freezing during test, etc.).
- Adversarial relationship with students as the gatekeeper of the points. Significant time lost in class and office hours negotiating partial credit rather than improving on their mistakes.
- Some students had a decline in motivation after a low quiz score / scores.
- Significant number of students taking mental health days to avoid assessments.
- Some students failed every assessment, but passed the course due to partial credit, leaving them completely unprepared for the next course in the sequence.

Major Changes

I didn't change anything about the content or the way I taught; only the grading system. Here are the major changes.

- Scores on assessments no longer based on points or percentages. Instead, there is a ternary scoring system, with two levels of passing: "Mastered", "Proficient", or "Not yet proficient" on a given learning target being assessed.
- Every learning target can be re-assessed (different problems, similar difficulty) without grade penalty. That is, there is no penalty for needing more time / practice to reach a learning target. All that matters is demonstrating evidence of mastery by the end of the semester.
- Grades only reflect understanding and not "behavior". That is, grades are not (directly) impacted by completion of HW, classroom and/or online participation, turning in late work, etc.
- Note that expectations have been raised: it is no longer possible to pass the course via partial credit. Students must actually meet certain expectations on a majority of the learning targets.

How it went

- Students far less stressed / anxious. Class and office hours were a lot more relaxed, fun, and productive.
- Supportive relationship with students, rather than adversarial.
- Motivation was through the roof. Everyone, from the most prepared students to the least, learned a lot more calculus.
- I actually saved a ton of time creating assessments and grading them.

Designing the grading system

I found the following two blogs very helpful:

1. gradingforgrowth.com
2. rtalbert.org

The latter has a series of posts ("Building Calculus") on designing a first year calculus course using mastery grading (these posts may be useful for other disciplines as well). The author also maintains a github repository with all of his course materials and assessments (see https://github.com/RobertTalbert/calculus). My grading system was heavily influenced by these blog posts, but it wasn't an exact copy and I didn't use any of his materials or assessments (his course was online, flipped, very different textbook, etc.).

Step 1: Writing the Learning Objectives

"Having clear, measurable learning objectives is the essential first step in a well-designed course. This is because I am eventually going to design my learning activities so they align with those objectives and do the same for my assessments, and even use the learning objectives to guide my selection of course materials and technological tools."
Robert Talbert, https://rtalbert.org/building-calculus-learning-objectives/

Talbert suggests writing learning objectives in two steps:

- **Course-level objectives:** These are the global, overarching "big picture" items that students should master as a result of taking the course.
- **Module-level objectives:** These are the finer-grained objectives focused on specific content tasks, connected to specific units or "modules" of the course.

Both sets of objects need to be clear and measurable (avoid words like "know", "understand", "appreciate"). The module level objectives should all be assessed.

Learning Objectives for BC Calculus I/II

- I started with IMSA's Mathematics Learning Standards. These look helpful for writing, but are not specific to any particular course and are not clear and measurable. E.g.,

  D.1. *Students studying mathematics at IMSA demonstrate awareness of the inter-connectedness of mathematical thought in inter- and intra-disciplinary settings by understanding that mathematics is a system of interconnected ideas. [SSL-III.B,III.C,IV.C; CCSSM: P7,8; NCTM-9.2]*

- Writing module-level learning targets was pretty easy. I just included all learning targets from the AP Calculus BC Exam Description that we will cover in the first semester, as well as other learning targets that the math department deems important.

From my syllabus:

Course Schedule

Here are the major divisions of this course:

- **Preliminaries**
- **Limits and Continuity**
- **Derivatives**
- **Applications of Derivatives**
- **Integration and Integration Techniques**

Course Content

There are 31 learning targets (16 of these designated "core" learning targets) in the course, which fall under the following course level objectives:

Course Level Objectives

1. **Limits (L)**: Explain, calculate, and apply the concept of limits.
2. **Derivatives (D)**: Explain and interpret the meaning of the derivative of a function.
3. **Theorems (T)**: Prove and apply theorems about the real numbers, continuous functions, and differentiable functions.
4. **Derivative Calculations (DC)**: Prove and apply theorems to calculate derivatives efficiently.
5. **Derivative Applications (DA)**: Use derivatives to solve real-world application problems.
6. **Integration (I)**: Explain, calculate, and apply the definite integral.

Learning Targets

Limits (L): Explain, calculate, and apply the concept of limits. **(5 total, 3 core)**

- L.1: (CORE) I can find the limit of a function at a point using numerical, graphical, and analytical methods.
- L.2: (CORE) I can find the limits at infinity, infinite limits, and one-sided limits using numerical, graphical, and analytical methods and interpret the corresponding behavior of the function.
- L.3: I can find limits using the squeeze theorem.
- L.4: (CORE) I can determine where a function is continuous using the definition, and I can classify discontinuities.
- L.5: I can identify limits in indeterminate form and apply L'Hopital's Rule to evaluate them.

Derivatives (D): Explain and interpret the meaning of the derivative of a function. **(5, 3 core)**

- D.1 (CORE): I can find the derivative of a function, both at a point and as a function, using the definition of the derivative.
- D.2 (CORE): I can use derivative notation correctly, state the units of a derivative, estimate the value of a derivative using difference quotients, and correctly interpret the meaning of a derivative in context.
- D.3 (CORE): Given information about f, f', or f'', I can correctly give information about f, f', or f'' and the increasing/decreasing behavior and concavity of f (and vice versa).
- D.4: I can determine where a function is continuous or differentiable given a graph or formula of the function and explain my reasoning.
- D.5: I can find the equation of the tangent line to a function at a point and use the tangent line to estimate nearby values of the function.

Derivative Calculations (DC): Prove and apply theorems to calculate derivatives efficiently. **(6, 3 core)**

- DC.1 (CORE): I can compute derivatives correctly for power, polynomial, and exponential functions and the sine and cosine functions, and basic combinations of these (constant multiples, sums, differences).
- DC.2 (CORE): I can compute derivatives correctly for products, quotients, and composites of functions.
- DC.3: I can compute derivatives correctly using multiple rules in combination.
- DC.4: I can compute the derivatives correctly for logarithmic, trigonometric, and inverse trigonometric functions.

- DC.5: I can compute the derivative of an implicitly-defined function and find the slope of the tangent line to an implicit curve.
- DC:6: (CORE) I can calculate higher-order derivatives of a function.

Derivative Applications (DA): Use derivatives to solve real-world application problems.
(4, 3 core)

- DA.1 (CORE): I can find the critical points and potential inflection points of a function, apply the First and Second Derivative Tests to classify the critical points as local extrema, determine where the function is increasing and decreasing, classify the possible inflection points, determine intervals of concavity of the function, and use this data to sketch a graph of the function.
- DA.2 (CORE): I can use the Extreme Value Theorem to find the absolute maximum and minimum values of a continuous function on a closed interval.
- DA.3 (CORE): I can set up and use derivatives to solve applied optimization problems.
- DA.4: I can set up and use derivatives to solve related rates problems.

Integration (I): Integration and techniques of integration. **(5 total, 2 core)**

- I.1: I can calculate the area between curves, net change, and displacement using geometric formulas and Riemann sums.
- I.2: I can explain the meaning of each part of the definition of the definite integral in terms of a graph, and interpret the definite integral in terms of areas, net change, and displacement.
- I.3: (CORE) I can evaluate a definite integral using geometric formulas and the Properties of the Definite Integral.
- I.4 (CORE): I can evaluate a definite integral using the Fundamental Theorem of Calculus.
- I.5: I can correctly antidifferentiate basic functions and identify antiderivatives.

Theorems (T): Prove and apply theorems about the real numbers, continuous functions, and differentiable functions. **(6, 2 core)**

- T.1: I can write a proof by contradiction.
- T.2: I can calculate suprema and infima.
- T.3: I can write an ϵ-δ proof.
- T.4 (CORE): I can explain the behavior of a function on an interval using the Intermediate Value Theorem.
- T.5: I can explain the relationship between differentiability and continuity.
- T.6 (CORE): I can justify conclusions about functions by applying the Mean Value Theorem over an interval.

Common Concerns

Claims: "Mastery grading only focuses on mechanical calculations." "Mastery grading artificially breaks down multi-step problems into single steps, which of course everyone can master, but doesn't focus on the whole."

My response: This has nothing to do with the grading system, but with how you set your learning targets and expectations. For example, one can define learning targets like this:

D.1: I can calculate the derivative of a power using the Power Rule.
D.2: I can calculate the derivative of a sum using the Sum Rule.

and just drill the same problems over and over with different numbers, or one can define learning targets like this:

D.1. I can identify the derivative rule or rules to apply to a variety of functions and use these to correctly calculate the derivative.
D.2: I can compute derivatives correctly using multiple rules in combination.

and practice these "big picture" skills while building computational fluency.

Common Concerns

Claim: "Mastery grading requires too many assessments and reassessments. This takes up too much class time, which takes away from learning."

My response: Here are some things I have done to avoid these issues:

- The AP Calculus BC Exam description had 40-something learning targets relative to BC 1 before I even added any. Since I committed myself to assess all learning targets in my syllabus, I condensed many of them. This cuts down on the number of assessments. For example,

  DA.1 (CORE): I can find the critical points and potential inflection points of a function, apply the First and Second Derivative Tests to classify the critical points as local extrema, determine where the function is increasing and decreasing, classify the possible inflection points, determine intervals of concavity of the function, and use this data to sketch a graph of the function.

- I saved even more class time by only assessing the core learning targets in class. I assessed the non-core learning targets more informally (e.g., take-home, walked around with a clipboard during class and observed student work). I give reassessments outside of class: midday in the math study area if there are many students taking it, in the math office or testing center for individuals.

Step 2: Assessments and Grading

Very briefly, mastery grading is an umbrella term that refers to grading practices that share some common characteristics:

- Typically, student work is not graded using points, but instead is evaluated relative to clearly-stated criteria that describe acceptable quality. The grade is assigned using a binary determination of whether the work meets the criteria or doesn't. Sometimes more finely-graded rubrics are used.
- Since there are no points, there's no concept of partial credit. Instead, students get significant, helpful, actionable feedback from their instructor that gets them thinking about how to improve.
- Finally, mastery grading builds in ways for students to take the feedback and revise and resubmit their work, in a feedback loop that continues until the work has met the criteria (or the student runs out of opportunities).

Or, as Tri-County Early College phrased it: "All assignments must be completed at a level of competency and are in-play as long as that takes (i.e. grades are never used as a punitive measure and zeros are never given)."
Robert Talbert, https://rtalbert.org/building-calculus-the-grading-system/

Following these practices, I got rid of points, but I had two sets of expectations for each learning target: Proficiency and Mastery.

Checkpoints: General Expectations for Mastery

- Prerequisites must be used correctly. That is, there can be no significant algebra/trig/precalculus mistakes.
- Mathematical notation must be used consistently and correctly. Any solution not employing the proper notation cannot score higher than a 1.
- All relevant work / steps must be shown clearly and the final answer clearly indicated.
- When using a theorem, it must be *concisely* explained (do not write a book) why all necessary hypotheses hold..
- Writing should be included whenever warranted (e.g., in justifying a conclusion), and should be clear and easy to follow (again, please be concise - do not write a book). Any relevant graphs or diagrams should be included and properly labeled, if applicable.
- An appropriate method of solution should be used and the solution should be correct, up to 1-2 insignificant errors (e.g., copying down a sign wrong or something of that nature, as long as the error doesn't greatly simplify the rest of the problem).
- In general, it should be easy for me to tell what you are doing, that you know what you are doing, and that you can clearly and concisely communicate what you are doing (through an appropriate combination of writing, notation, showing work/steps, and/or graphs/charts/diagrams, as applicable).

Roughly, my expectations for proficiency on a learning target are to demonstrate one of two things: master a more basic problem, or make significant progress on a hard problem, but not quite reach the expectations for mastery.

Checkpoints: Examples

BC 1 Name: ______________________________

L3, L4, T3 Checkpoint

Instructions. Solve each problem showing all work and/or explaining all reasoning. Make sure to write in complete sentences and to use proper notation. **These problems must be completed individually, without outside help. You may discuss them with me.**

Learning Target L.3: I can find limits using the Squeeze theorem.
Learning Target L.4: (CORE) I can determine where a function is continuous using the definition, and I can classify discontinuities.
Learning Target T.3: I can explain the behavior of a function on an interval using the Intermediate Value Theorem.

1. (L.3, P) If $4x-9 \leq f(x) \leq x^2-4x+7$ for $x \geq 0$, find $\lim_{x\to 4} f(x)$.

2. (L.3, M) Find $\lim_{x\to 0} f(x)$, where $f(x) = \begin{cases} 0, & \text{if } x \text{ is rational,} \\ x^2, & \text{if } x \text{ is irrational.} \end{cases}$

Checkpoints: Examples

5. (DC.2, DC.3) Compute the derivative of each of the following functions. Show some work, but DO NOT simplify your final answer.

   (a) $y = \sqrt{x}\sec(x)$

   (b) $y = x\cos(x) + \pi e^x$

   (c) $y = -3x^{700}$

   (d) $y = (x + 5x^{\frac{2}{3}})(e^{2x} - \cos(3x))$

   (e) $y = \dfrac{2x+1}{3x+2}$

How quizzes go using this system

- I schedule a retake (different problems, but similar difficulty) one week after each checkpoint (taken in math study area during midday).
- Most students reach at least proficiency on all learning targets on a given checkpoint, but most do not reach mastery on all of them.
- Nearly all students improve significantly on the retake, though some still do not reach mastery on all learning targets.
- In stark contrast to the previous semester, **students now almost never miss assessments**. Indeed, the incentive structure is now completely reversed: there is now absolutely no downside to taking an assessment. A student can fail every single problem on their first try and still earn 100% later. On the other hand, if they miss an assessment, they lose an opportunity for feedback and then have to work twice as hard to catch up since they have to learn the new material while studying for the retake. (Note that some versions of mastery grading are self-paced; i.e., a student doesn't move on to Unit 2 until mastering Unit 1. I am not doing this.)
- **Claim:** "Giving retakes incentivizes students to not take the assessments seriously the first time." **My Response.** I have not observed an increase in students not taking assessments seriously. In my experience, everyone understands that mastery is a very high expectation and nearly everyone tries their best on each attempt.

Creating assessments is a LOT faster

With traditional grading, creating an assessment is largely driven by points and ensuring fairness:

- In making a points-based assessment, one must add enough questions to reach a point quota, say 40 points, without making the test too long (students can't recover points if they don't finish or rush and make mistakes). It takes a lot of additional time and effort to fit these auxiliary constraints (which often fails to some extent anyway).
- Scarcity of points greatly incentivizes cheating, so multiple versions need to be made in this way, with different questions but trying to ensure the new version is of similar difficulty.
- Assessments need to be carefully proofread ahead of time to ensure there are no errors or unclear questions which could cause students to lose points that they can't get back. If there is an issue with the test, then it takes time and meetings to figure out how to rectify the situation fairly.
- **With mastery grading, these are all non-issues.** I just put on the assessment what I need to assess, and I'm done. If a student doesn't finish, they can just solve whichever problems they don't finish on the retake for full credit. If there is a typo on some version of the exam or a question that is unclear, those students can just solve new problems for full credit; there is no issue of fairness.

Grading assessments is a lot faster

- With points-based assessments, to ensure consistency instructors need to develop a rubric for each question on the assessment to determine how to nickel and dime students for every type of mistake. As different mistakes arise that were not anticipated ahead of time, instructors must often consult with each other further.
- For multi-step problems where a student makes a mistake in the first step, instructors should really use their mistake and re-solve the entire problem to make sure we give them appropriate credit for the rest of the problem and only take off points for independent mistakes.

Example: Rubric

2)
+4 for switching bounds correctly
+3 for integration work
+1 for final answer

I had sooooo many people who put y = \sqrt{x} on their picture but coincidentally, it gives the same bounds so they got it right. Did you take off for this? I don't think I would since some people didn't sketch the region (and we didn't ask).

3a)
+1 correct integrand
+3 for bounds

3b)
+1 correct integrand
+3 for bounds

3c)
+3 for integration work
+1 final answer

I seem to have lot of students do dz dr dtheta - I've been pretty lenient on how much of the u sub they needed to show, basically letting them slide if they got to an integral where they could do it. But I could be convinced to take off

I think I want to take off ½ if they don't show some steps i.e. magically integrate (25-z^2)^2 without any work.

One student (SP) integrated dzdrdtheta but then still got r^2+¼ r^4 from the first step which doesn't make sense. Her bounds are correct at least….

All of this is incredibly time-consuming and is caused by the traditional grading system, as we must assure that points are distributed accurately and fairly.

Example: Data

After grading, instructors need to calculate and compare statistics to check for disparities, including ones that could be caused by inconsistent grading.

BC1																		
Spring 2020			A	B														
	85	*TOTAL*	*40*	*45*	**24.16**	**80.55%**	**MEAN**	57%	80%	62%	82%	88%	52%	96%	89%	97%	90%	92%
Last Row		**A**	**20.00%**	**24.44%**	**24.50**	**81.67%**	**MEDIAN**	50%	100%	100%	100%	100%	67%	100%	100%	100%	100%	100%
95		**B**	**35.00%**	**33.33%**	**23.50**	**78.33%**	**MODE**	100%	100%	100%	100%	100%	17%	100%	100%	100%	100%	100%
		C	**35.00%**	**26.67%**	**30.00**	**100.00%**	**HIGH**	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
		D	**10.00%**	**15.56%**	**12.00**	**40.00%**	**LOW**	0%	0%	0%	0%	0%	0%	0%	0%	50%	33%	0%
Intro, R-O-C, and limits																		
Quiz 1	1/28/2020				30	100.00%	A	3	2	2	3	3	3	2	3	3	3	3
Last Name	**First Name**	**Mod**	**Version**	**Instructor**	**Total**	**Percent**	**Grade**	**1**	**2**	**3**	**4a**	**4b**	**5**	**6**	**7a**	**7b**	**8a**	**8b**
Appasani	Sri Lalana	2	A	Sorescu	23	76.67%	C	1.5		1	0.5	1	2.5		0.5			
Baxamusa	Shiraz	2	A	Sorescu	28	93.33%	A	1.5					0.5					
Cordero	Kevin	2	A	Sorescu	24.5	81.67%	B-	1	1	1			2.5					
Eldridge	Mirella	2	A	Sorescu	25	83.33%	B	2					1			1	1	
Illimoottil	Mathew	2	A	Sorescu	23.5	78.33%	C+		2	2			2.5					
Johnson	Brett	2	A	Sorescu	23.5	78.33%	C+	0.5	0.5	1		2	2.5					
Mahesh	Shreya	2	A	Sorescu	28	93.33%	A						1		1			
Matthews	Wesley	2	A	Sorescu	26	86.67%	B	1.5		2			0.5					
McClain	William	2	A	Sorescu	25.5	85.00%	B	1.5					0.5				1	1.5
Patel	Ruchi	2	A	Sorescu	24.5	81.67%	B-	3			1	1	0.5					
Puchitkanont	Ava	2	A	Sorescu	21	70.00%	C-			2	2.5	1	2		0.5	1		
Si	Fania	2	A	Sorescu	21.5	71.67%	C-	2		2			3		1		0.5	
Abdullah	Jaelynn-Darshawn	3	A	Fogel	27	90.00%	A-	2	0	0	0	0	1	0	0	0	0	0
Bates	Jade	3	A	Fogel	17.5	58.33%	D	3	0	1	2.5	1	3	0	2	0	0	0
Bolsinger	Brooke	3	A	Fogel	22.5	75.00%	C	1.5	1	0	1	1	3	0	0	0	0	0
Bravo	Marco	3	A	Fogel	24	80.00%	B-	2	0	2	0	1	0	0	1	0	0	0
Casas	Abraham	3	A	Fogel	23.5	78.33%	C+	2.5	0	1	0	1	1	0	1	0	0	0
Dumitrescu	Francesca	3	A	Fogel	21	70.00%	C-	1.5	0	1	2.5	3	1	0	0	0	0	0
Grotke	Jackson	3	A	Fogel	23.5	78.33%	C+	1.5	0	1	0	1	3	0	0	0	0	0
McDonald	Austin	3	A	Fogel	26	86.67%	B	2	0	0	1	0	0.5	0	0.5	0	0	0
Michel	Diego	3	A	Fogel	22	73.33%	C	1.5	1	0	0	1	3	0	0	0.5	1	0
Musku	Harshini	3	A	Fogel	28	93.33%	A	1	0	0	0	0	1	0	0	0	0	0
Padilla	Jiliann	3	A	Fogel	25	83.33%	B	0.5	0.5	1	2	0	0	0	0.5	0.5	0	0
Rodriguez	Elasia	3	A	Fogel	20	66.67%	D	2	1	0	3	2	1	1	0	0	0	0

Mastery grading is significantly faster

Again, all of these are non-issues with mastery grading:

- Grading a class of 20-30 assessments takes me just a few minutes: each solution either meets the expectations or it doesn't. I just circle where the solution started to go wrong, and then move on. DO NOT write feedback on the paper - this is very time-consuming and mostly unnecessary. I just note any common mistakes, which I point out to the class when I hand them back. Students are going to check their solutions with their classmates anyway. If they are still really lost, they can always ask me in class or in office hours.
- Since grading is binary, consistency is pretty much automatic, so there is no need for a rubric. For a solution which is borderline, I usually just default to making them do the retake. Repetition is good for them anyway! Even if two papers aren't graded consistently, the student who didn't receive credit can just take the retake and still get full credit; there is no issue of fairness.
- There is no need for a meeting to discuss grade distributions.

Retakes

Question: Doesn't having retakes add so much time to grading that this isn't worth it?

Answer: Not at all. Students only need to retake the learning targets they did not master, so there is less to grade the second time. Moreover, virtually everyone improves a lot on the retake, with most solving the problems perfectly, which makes grading even faster.

In the past I always needed to make a second version for absences anyway, so making a second version is no additional work (actually it is less since it is much faster to make a second version in this system, as noted earlier).

Cheating?

Under points-based grading, people cheat because it's high-risk/high-reward. You might get caught and face severe consequences, but you might not get caught and accumulate yourself some serious points. On the other hand, mastery grading is predicated upon, among other things, having a robust revision policy for most or all forms of graded work in a course. If you can revise and resubmit just about any significant piece of work — multiple times, and get helpful feedback each time until you're happy with your grade, then the value proposition of cheating becomes empty.
Robert Talbert https://rtalbert.org/mastery-grading-and-academic-honesty/

- I agree this this assessment. Overall, I did not observe a noticeable increase in cheating.
- On my take-home assessments I instructed students not to collaborate, and reminded them that they could have multiple attempts for full credit. I did have 2-3 instances of receiving solutions which were clear copies of another student's. In the rare cases when this happened, I spoke with the students involved and reminded them that I needed to see that they could solve the problems on their own, and I made them solve the retake. For the most part, the solutions I received looked unique.
- I didn't catch any cheating on in-class assessments.

Motivation

- Mastery grading gives students hope. They develop a growth mindset and take pride in their improvements. I had students last fall who I am sure would have given up and failed under the traditional grading system. With the new grading system, they kept working hard and improving all semester, finishing the course with a 'B'.
- It took them significantly more help, practice, and tries than some of their peers, but they eventually could meet the same expectations as everyone else.
- On the other end of the spectrum, many students wanted to master *everything*, even after securing a guaranteed A.
- Overall, I believe the increased motivation resulted in every single student learning calculus better than they would have under the traditional grading system with everything else kept the same.

Other graded assignments

- IMSA has Mathematics Learning Standards tied to the IMSA SSLs, which foster collaboration and inquiry. To support these goals, I also assign Application and Extension Problem Sets (AEPs) which dive deeper into the theory, explore applications in various fields, etc. Students work on these in pairs and submit their solution together. These are graded on an EMPX rubric (E=excellent, M=meets expectations, R=revisions needed, X=not assessable). Students receive feedback and may submit revisions to be re-graded within one week. I do give partial credit for an 'R', so that students don't spend an excessive amount of time on these. (Example: Students proved Kepler's Laws of planetary motion in MVC and applied them to solve real-world problems.)
- There is a cumulative final exam consisting of two sections: a mandatory section covering the core learning targets and an optional section covering the non-core learning targets. Only the mandatory section is used to calculate the final exam grade. Each question is at the mastery level and is worth 2 points, though a student can still earn 1 point if they make sufficient progress. The total points earned are converted to a percentage, with proficiency on all core learning targets but mastering none set to 70% (i.e., just passing).
- The final exam is also a final opportunity to level up on any learning targets that had not yet been mastered by the end of the semester. I do not level anyone down in the event that they fail to earn full points on a learning target which they had already mastered.

Assigning a letter grade for the course

At IMSA we assign an A,B,C, or D at the end of the semester, with C the lowest passing grade. I don't assign +/− grades.

Most mastery grading systems assign letter grades using a table, such as this one:

Grade	Learning Targets with at least Proficiency Rating	Learning Targets with Mastery Rating	AEPs completed with M or E
A	16/16	29/31 including all 16 core	6/8
B	16/16	25/31	4/8
C	16/16	18/31	2/8

A grade of D is assigned if none of the rows has been fully completed.

However, as grades/interims must be entered in powerschool I needed to have a running percentage grade for the course. I therefore devised a formula for the course grade that more or less reproduced the table above.

Calculation of the running percentage grade

I kept the same category weights:

- Checkpoints 60%
- AEPs 20%
- Final Exam 20%

I entered each non-core checkpoint out of 5 points: M=5/5, P=4/5, N=0/5. Core checkpoints counted double; i.e., M=10/10, P=8/10, N=0/10.

AEPs were also entered out of 5 points: E=5/5, M=4/5, R=3.5/5, X=0/5.

The final exam score was entered out of 100%, as described above.

Benefits. Parents/students/faculty/admin can check the student's progress at any time by looking at a percentage, as they are used to doing, rather than a complicated table. At-risk students are automatically flagged so that they can proactively receive additional support.

Issues. The running percentage is highly volatile. For most students it drops a lot after an assessment (sometimes several letter grades), and then goes back up after the retake. (However, this might motivate students to study hard for the retake!) Combining with the amount of time on the at-risk list is a better indicator of progress. What we really need is a mastery transcript, which I hope to look into.

End of the Semester Stuff

- With traditional grading, often students with a borderline grade at the end of the semester (e.g., 68%) would look to gain a couple points here and there to pass.
- With my mastery grading system, I make sure struggling students are working to master the core learning targets, as these are the most important for moving on, rather than looking for any random points.
- After the semester, I can send the instructor of the next course each student's mastery levels, so they have a much more precise picture of their incoming students' preparation. Just knowing the letter grade or even the percentage out of 100%, is much less informative.

Resources

- Grading for Growth: https://gradingforgrowth.com/
- Thomas Guskey's Webpage: https://tguskey.com/
- Robert Talbert's Blog: https://rtalbert.org/
- Jesse Stommel's Blog: https://www.jessestommel.com/
- Mastery Grading FAQ: https://docs.google.com/document/d/1oWBOxRhU3kqizhJcbSYFc-33p_HyftA4FYh4zI6ZUA/edit

Questions?