Learning Goals and Accumulation Grading in Calculus I

LEARNING GOALS

Here is a sample of learning goals from my calculus I class in Fall 2014.

D-level goals

Learning Goal	A (1)	Q (2)	Q (3)	Q (4)
D6: I know when to use a limit.				
D7: I know when to use a derivative.				
D8: I know when to use a integral.				

CD-level goals

Learning Goal	A (1)	Q (2)	Q (3)	Q (4)
CD3: I can estimate limits from graphs.				
CD5: I can estimate derivatives numerically.				
CD7: I can use Riemann sums to estimate integrals.				

C-level goals

Learning Goal	A (1)	Q (2)	Q (3)	Q (4)
C1: I can identity the relationship between a function's value and its limit.				
C5: I can find derivatives using the definition of derivative.				
C6: I can sketch f, f', or f'' given a graph of f, f', or f''.				

BC-level goals

Learning Goal	A (1)	Q (2)	Q (3)	Q (4)
BC5: I can use the Product Rule.				
BC8: I can take derivatives of polynomials and rational functions.				
BC9: I can take derivatives of trigonometric functions.				
BC16: I can find antiderviatives of exponential functions.				
BC17: I can find the equation of a tangent line.				

B-level goals

Learning Goal	A (1)	Q (2)	Q (3)	Q (4)
B2: I can use linear approximation.				
B3: I can find extrema.				
B6: I can determine intervals of concavity.				
B15: I can use FToCI.				
B16: I can use FToCII.				

AB-level goals

Learning Goal	A (1)	Q (2)	Q (3)	Q (4)
AB1: I can write δ-ϵ proofs for linear functions.				

A-level goals

Learning Goal	A (1)	Q (2)	Q (3)	Q (4)
A1: I can solve Related Rates problems.				
A2: I can write δ-ϵ proofs for quadratic functions.				

ACCUMULATION GRADING

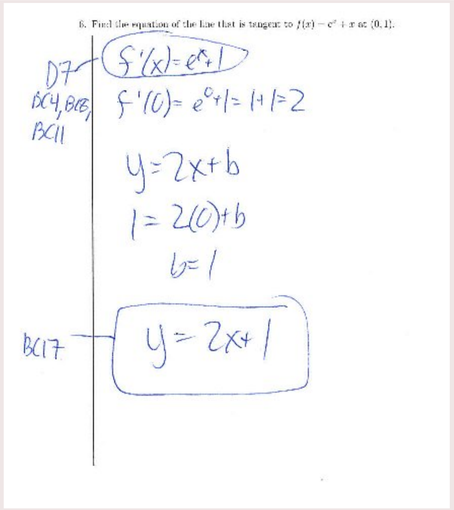
Issues with Traditional Grading

1. Grades lack intrinsic meaning.
2. Students are expected to learn the course content at the same pace. Consider:
   - Student 1 gets 85% on all four exams.
   - Student 2 gets 100% on the first exam, 90% on the second, 80% on the third, and 70% on the fourth.
   - Student 3 gets 40% on the first exam, 100% on the second, 100% on the third, and 100% on the fourth.
3. Grading does not give students feedback on how to improve.
4. Grading is too "high stakes."
5. Students encouraged to "bluff" for partial credit.
6. Cramming is rewarded.
7. There is not enough accountability to learning.

Accumulation Grading

- All grading is binary: students either get 100% on the assignment, or they get 0% on the assignment.
- Students are given multiple chances to demonstrate mastery of Learning Goals
- Students must "tag" an answer with a Learning Goal in order to get credit for it (metacognitive benefits?).
- Students must demonstrate mastery over time

Example



Benefits of Accumulation Grading

1. Grades are based on what students know, rather than what they do not know.
2. Students are allowed many chances to demonstrate mastery of material.
3. Accountability: there is no substitute for learning the most important topics.
4. Grades based on how much they know at *the end* of the semester

ASSESSMENT

Results

- Calculus Concept Inventory (CCI) pre- and post-test
- Similar to Force Concept Inventory (FCI) in physics
- Calculate "average normalized gains" of each class (the percentage of material the student learning *out of the material they did not already know*)

$$\langle g \rangle = \frac{\text{Final} - \text{Initial}}{\text{Total} - \text{Initial}}$$

- Sample question: If you know that a function $f(x)$ is positive everywhere, what can you conclude from that about the derivative $f'(x)$?
  1. the derivative is positive everywhere
  2. the derivative is increasing everywhere
  3. the derivative is concave upward,
  4. you can't conclude anything about the derivative

Results

- Typical "Traditional Lecture" classes have average normalized gains of 0.08–0.23 on CCI
- Typical "Interactive Engagement" classes have average normalized gains of 0.30–0.44 on CCI
- Recent courses at CSBSJU (*B* indicates my class):

n	26	22	19	15	5	23	21	8	2	26	15	20	20
$\langle g \rangle$	0.29*B*	0.24*B*	0.14	0.15	0.19	0.19	0.15	0.09	0.03	0.01	0.09	0.21*B*	0.14*B*

Bibliography

- J. Epstein, Development and validation of the Calculus Concept Inventory, in *Proceedings of the Ninth International Conference on Mathematics Education in a Global Community*, September 7–12, 2007, edited by Pugalee, Rogerson, and Schinck
- J. Epstein, The Calculus Concept Inventory—measurement of the effect of teaching methodology in mathematics, *Notices of the AMS*, **60**(8), 2013, 1018–1026.
- J. Epstein, "Calculus Concept Inventory," Field-tested Learning Assessment Guide, `http://www.flaguide.org/tools/diagnostic/calculus_concept_inventory.php`.

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