MASTERY-BASED ASSESSMENT IN ALGEBRA

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OUTLINE: MASTERY-BASED ASSESSMENT

- Introductions: name, where you are from, what you do (job title), what you really do (not a job title)
- Why we started this project
- How we run the courses in the program
  - Rubrics
  - Learning objectives
- Challenges along the way
- What's next
- Summary of key steps for implementing Mastery-Based Assessment

INSPIRATION

- Dissatisfied with the status quo
- Inspired by PRIMUS special issue on "Implementing Mastery Grading in the Undergraduate Mathematics Classroom" https://www.tandfonline.com/upri20
- Challenged by Grading for Equity: What It Is, Why It Matters, and How It Can Transform Schools and Classrooms by Joe Feldman
- Is what we've always done really the best we can do?

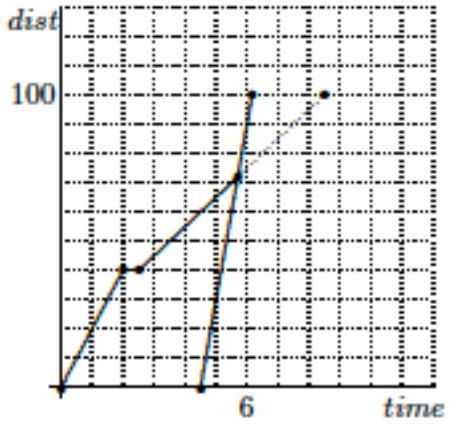
RATIONALE

- Shortcomings of high-stakes testing and traditional grading based on averaging and the 100-point scale
- Equity
- Identity as a math learner
- Growth mindset

EXETER MATH AND PROBLEM-BASED LEARNING

- First term of 9th grade is Pass/No Pass
- Transition courses for all 9th graders in Fall term (11 weeks)
- 11T covers first third of Book 1, 12T covers first two-thirds of Book 1, 13T covers all of Book 1 (lots of early problems are skipped)
- 120 follows 11T, 130 follows 12T and 120

145. At noon one day, Allie left home to make a long bike ride to the family camp on Mud Lake, a distance of 100 km. Later in the day, the rest of the family packed some things into their van and drove to the lake along Allie's bike route. They overtook Allie after driving for 1.2 hrs, stopped long enough to put Allie and bicycle in the van, and continued to the camp. Refer to the graph as you answer the following questions about the day's events:



(a) Allie pedaled at two different rates during the biking part of the trip. What were they?

(b) After biking for a while, Allie stopped to take a rest. How far from home was Allie then? How long did Allie rest?

(c) How far from home was Allie when the family caught u

(d) At what time did the family arrive at the camp?

(e) At what time would Allie have arrived, if left to bicycle

(f) What distance separated Allie and the rest of the famil

146. The perimeter of a rectangle is 100 and its length is x. width of the rectangle?

BOOK 1 SAMPLE

147. When a third of a number is subtracted from a half of the same number, 60 is the result. Find the number.

148. Draw the segment from $(3,1)$ to $(5,6)$, and the segment from $(0,5)$ to $(2,0)$. Calculate their slopes. You should notice that the segments are equally steep, and yet they differ in a significant way. Do your slope calculations reflect this difference?

149. Eugene and Wes are solving the inequality $132 - 4x \leq 36$. Each begins by subtracting 132 from both sides to get $-4x \leq -96$, and then each divides both sides by -4. Eugene gets $x \leq 24$ and Wes gets $x \geq 24$, however. Show who is correct by substituting $x = 0$ into both the original inequality and the answer.

150. (Continuation) Cameron now suggests that the problem could have been done by solving the equation $132 - 4x = 36$ first. Complete the reasoning behind this strategy.

151. (Continuation) Deniz remarks, "A tricky thing about inequalities is when you try to multiply them or divide them by negative numbers, but you can avoid this altogether. Cameron just told us one way to avoid it, and there is another way, too." Explain.

152. Solve the following inequality for x: $2(1 - 3x) - (x - 5) > 1$

HOW WE RUN THE COURSE

- Each class is a PBL day with homework presentations
- Assessments consist of a weekly 30-minute quiz or a bi-weekly 60-minute quiz
- Reassessments are offered within two weeks of the quiz
- Additional (>2) assessments are the exception, not the rule

RUBRICS

- Four possible outcomes for each learning objective:

  Incomplete

  Progressing

  Needs Revision

  Mastery

- Behavioral objectives are not in the formal learning objectives

LEARNING OBJECTIVES MATRIX

Learning Objectives Matrix for 11T Fall 2023

[redacted]

Mastery key: I = Incomplete; P = Progressing; NR = Needs Revision; M = Mastery

Category	Objective	I	P	NR	M	Comment
1) Number sense						
	1a) Number line problems and order				M	Q1A (9/22)
2) Rates, unit conversion, DRT problems, movement stories						
	2a) Conversion of units and rates		P		M	Q1A (9/22), Q2A (9/27)
	2b) DRT problem - solving for the unknown		P			Q2A (9/29)
	2c) Movement story - 2 lines with different rates and average speed					
	2d) Another DRT problem similar to 2b					
3) Percent problems						
	3a) With numbers and variables and equation, money and interest				M	Q1A (9/22)
	3b) Another percent problem similar to 3a					
4) Linear expressions						
	4a) Translating words into algebra				M	Q1A (9/22)
	4b) Using multiplication, distributive property, and adding like terms				M	Q2A (9/29)
5) Fractions						
	5a) Fraction simplification including sum and products and literal constants					

BIGGEST CHALLENGES

- How to keep away from deconstructing the course:
  - Maintain a focus on multi-step synthesis problems
  - Remain true to our foundational objectives in PBL
- Finding time for reassessments and extra help
- Convincing colleagues that this is effective and worth the extra work

END-OF-TERM GRADES

- At first we had too many learning objectives (37 reduced to 30)
- We used the number of **M**astery marks in matrix to assign ABCDE grades based on a 10% scale (roughly)
- We allow up to 4 of the **NR** marks to be counted as **M** if not cleared by the end of the term

ASSESSMENTS

- 3 – 4 questions per quiz (weekly); 6 questions per quiz (bi-weekly)
- Codes for learning objectives are indicated next to items, which match the entries in the Learning Objectives Matrix
- Grading a quiz is straightforward
  - Points are not assigned
  - Minimal correction is given

CASE STUDIES

Sample learning objectives matrices near the end of the course:

- RJ (130 Winter term)
- VV (130 Winter term)
- L (130 Spring term)
- M (130 Spring term)
- S (130 Spring term)

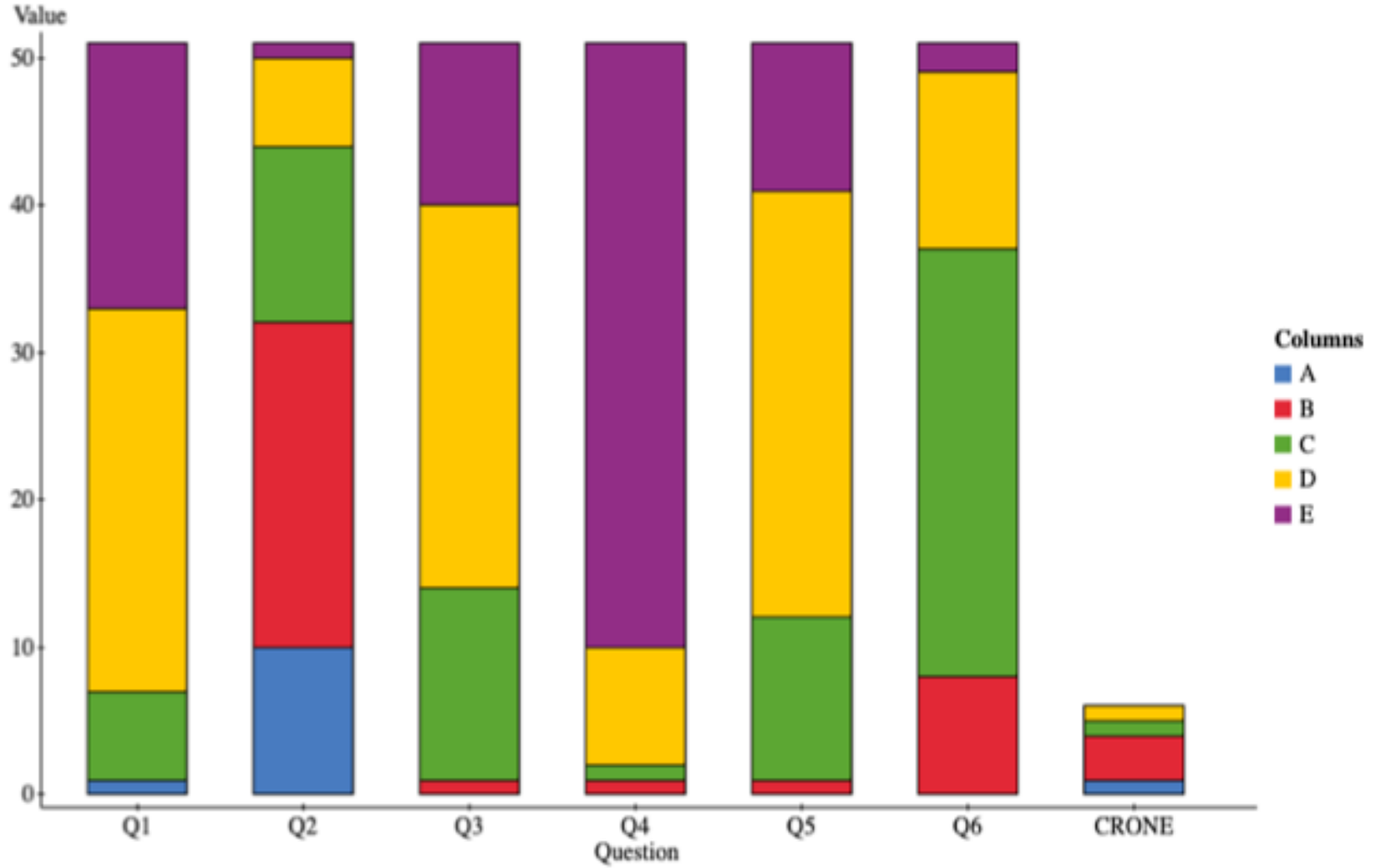
CHALLENGES (PART 2)

- Scheduling reassessments for over-scheduled people
- Advance work is substantial (but it gets better!)
  - Constructing syllabus
  - Building learning objectives matrix
  - Writing test bank with multiple items for each learning objective
- Don't lose sight of Plain Old Good (**POG**) teaching

INDICATORS OF SUCCESS

- Overwhelmingly positive reviews from the students
- Evidence of learning
- “Gaming” the system was rare
- Few students went for the minimum
- Ongoing research this year

PRELIMINARY RESULTS



SURVEY QUESTIONS

1. How well, if at all, do you understand the topics covered in MAT130?
a) Not at all well
b) Slightly well
c) Somewhat well
d) Quite well
e) Extremely well

2. How anxious, if at all, were you before in-class assessments in MAT130?
a) Not at all anxious
b) Slightly anxious
c) Somewhat anxious
d) Quite anxious
e) Extremely anxious

3. How accurately, if at all, did the results of in-class assessments reflect your knowledge in MAT130?
a) Not at all accurately
b) Slightly accurately
c) Somewhat accurately
d) Quite accurately
e) Extremely accurately

4. How beneficial to your learning, if at all, were opportunities to reassess in mathematics this year?
a) Not at all beneficial
b) Slightly beneficial
c) Somewhat beneficial
d) Quite beneficial
e) Extremely beneficial

5. How prepared, if at all, do you feel for your next mathematics course?
a) Not at all prepared
b) Slightly prepared
c) Somewhat prepared
d) Quite prepared
e) Extremely prepared

6. How confident, if at all, are you in your ability to be successful on mathematics assessments that do not use mastery-based grading?
a) Not at all confident
b) Slightly confident
c) Somewhat confident
d) Quite confident
e) Extremely confident

Crone's section only
How challenging, if at all, was the transition from mastery-based grading practices in the Fall and Winter to traditional point-based grading practices this term?
a. Not at all challenging
b. Slightly challenging
c. Somewhat challenging
d. Quite challenging
e. Extremely challenging

STUDENT QUOTE 1

“I think I was more comfortable with making mistakes, not being completely sure of an answer for a problem, and/or having tried my best for each problem even if I wasn't able to complete a solution.”

STUDENT QUOTE 2

"Not receiving normal grades in math last term, but instead receiving second chances made me always learn the concept in the end because I was encouraged to retake the failed problem. Because of this, stress was taken away, and the overall quality of work stayed the same as it has been this term."

STUDENT QUOTE 3

“Furthermore, the ability to re-take assessments convinced me that it's alright to make mistakes; as long as you understand them in the end, that's all that matters.”

REWARDS

- Mastery is achievable
- The emphasis is on growth
- Assessments are less stressful for students
- Lots of advance work is needed, but it pays off during the term
- ***This is not just about assessment; it's also about learning***

KEY STEPS

MASTERY-BASED ASSESSMENT

1. Decisions: Faculty team, student cohort, time frame, and syllabus
2. Construct the Learning Objectives Matrix
3. Set the Rubrics: **I**ncomplete, **P**rogressing, **N**eeds **R**evision, **M**astery
4. Decide on Passing standard and/or Grade ranges
5. Write the assessment items in advance
6. **Start the term and enjoy!**

THANK YOU!

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Problem-Based Learning and Exeter Math
https://www.exeter.edu/mathproblems

Math Teaching Materials

To read or print the problem sets below, you must install the Adobe Acrobat Reader, available for free here.

Courses		Last Updated	
Math 1	Problem Set	Aug. 21, 2023	Changes Math 1
Math 2	Problem Set	Aug. 21, 2023	Changes Math 2
Math 3-4	Problem Set	Aug. 21, 2023	Changes Math 3-4
Math 4-5	Problem Set	Aug. 21, 2023	Changes Math 4-5
Discrete Mathematics	Problem Set	Sept. 4, 2019	
Multivariable Calculus	Problem Set	Sept. 4, 2019	Changes Math 6

https://tinyurl.com/ASG-Conf