Mastery Based Testing

An Introduction and Observations from Implementation in a Variety of Levels of Mathematics Courses

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MAA Sectional Meeting
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Where it all began…. (for us)

Trip to MathFest 2016 with colleagues and students
Online resource

http://mbtmath.wordpress.com
Mastery based testing – the easy part

• Course content remains the same

• Content from entire course is broken in to “topics”

• We’ve used anywhere from 14 to 30 topics for a course
Mastery topics – Calculus II

1. Differential Equations
2. Applications of Integration
3. Sequences & Series
4. The Ratio Test
5. Power Series
6. Taylor Series
7. Applications of Series
8. Vectors
9. Dot & Cross Products
10. Applications of Dot & Cross Products
11. Vector-Valued Functions
12. Motion in Space
13. Surfaces in Space
14. Functions of Several Variables
15. Partial Derivatives
16. Double Integrals
17. Applications of Double Integrals
18. Double Integrals in Polar Coordinates
Points based testing

The process...
• Cover material for 2,3, or 4 weeks
• Give a test
• For each problem, assign points based on correctness
  • What does a 7/10 really mean compared to an 8/10??
• Mark up the test with corrections
• For a student with a 70% average, how do you best help them improve?

The outcome...
• Students carefully look at your comments – to see if they agree with your grading
• Content and assessment moves on to new material, previous material (possibly) revisited on the final
• A portion of the students grade is locked down
• Students begin asking if you will drop their lowest test score, or ignore earlier test scores if they show improvement
Mastery based testing – the mechanics

• Work on a topic is graded as either “mastered” or “not mastered”
  *(no points are used, there is no partial credit)*

• Once you master a topic, you need not ever attempt it again on future tests, including the final exam.

• If a topic is not mastered on a given attempt, it may be worked again at the next opportunity, no limit on attempts.

• There is no penalty whatsoever for multiple attempts being needed to master a topic.

• Test grade is calculated using proportion of topics mastered.
Testing / Grade Scale

Test 1: Topics 1-4
Test 2: Topics 1-9.
Test 4: Topics 1-18.
Final Exam: Topics 1-18.

On every Friday between tests you may work up to two topics.

Overall test grade is determined by the number of topics mastered.

<table>
<thead>
<tr>
<th># Mastered</th>
<th>18</th>
<th>17</th>
<th>16</th>
<th>15</th>
<th>14</th>
<th>13</th>
<th>12</th>
<th>11</th>
<th>10</th>
<th>9</th>
<th>8</th>
<th>7</th>
<th>6</th>
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<th>4</th>
<th>3</th>
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</thead>
<tbody>
<tr>
<td>Test Grade</td>
<td>100</td>
<td>96</td>
<td>92</td>
<td>88</td>
<td>84</td>
<td>80</td>
<td>76</td>
<td>72</td>
<td>68</td>
<td>64</td>
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<td>56</td>
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<td>40</td>
<td>30</td>
<td>20</td>
<td>10</td>
<td>0</td>
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</tbody>
</table>
Math 122  

Lines and Planes in Space  

Topic 10 v.2

Name__________________________________________________________

Find the equation of a line that lies in the plane $x - 2y + 3z = 10$.

Math 122  

Motion in Space  

Topic 12 v.1

Name__________________________________________________________

A projectile is launched horizontally at 1100 feet per second from a height of 5 feet above the ground. What will be the speed of the projectile when it strikes the ground?
What does mastery of a topic mean?

• It **does not** mean perfect.

• It **does** mean that you have demonstrated a full understanding of the topic, and that future work on the topic is not necessary.
The good...

• Clear content objectives
• Reduced test anxiety
• Intelligent studying, test preparation, and use of feedback
  - use of office hours changes dramatically
• Tenacity / perseverance
• Removal of artificial deadlines for understanding content
• A clear path to improvement of grade
• For the instructor – a clear measure of which material in the course
  students do or do not understand.
The (possibly) bad...

- Writing multiple versions of problems is more work initially but balanced by grading being substantially easier.
- Incredible opportunity for student procrastination.
- Not everything studied will be tested.
- Brutal on truly weak students.
- A student used to getting a “C” on everything may fail.
First experience

• Last fall
• Vector calculus
• 17 motivated students

I think that over the semester my enjoyment of mastery based testing continued to grow. The first day I was a bit nervous about testing be 100% or nothing but in the end it shows if you really understood the material and I think that's extremely beneficial, especially in mathematics.

I could always tell why I didn't get mastery - didn't integrate correctly, didn't check all critical points, had no idea what I was doing - it was always crystal clear.

I am proud to have taken part in the test run of mastery based testing. My grade may not have been stellar, but that's an issue with how I study, not the testing method.
Research Question

Does the benefit of, and acceptance of, mastery based testing vary among different student cohorts?

Fall 2017 – I am incorporating mastery based testing in 4 courses
• INQ 240 – Introductory Statistics (general education course)
• Math 122 – Calculus II
• Math 311 – Operations Research
• Math 332 – Applied Differential Equations
What could vary?

Quantitative data
• Grade distributions
• Mastery rates
  • by student
  • by topic
  • by version
  • vs. number attempted

Qualitative data
• Student effort
• Perseverance
• Test anxiety
• Fairness of grading
• Grade reflective of knowledge?
After Test 1

Number of Topics Mastered by Individual Students

After Test 2

Number of Topics Mastered by Individual Students

After Test 3

Number of Topics Mastered by Individual Students
Calculus II, Fall 2017

Current mastery rate by topic
Two different students in Calculus II – current progress on 13 topics covered

**Student 1**

22 attempts, 7 topics mastered

**Student 2**

20 attempts, 12 topics mastered
Preliminary Qualitative Observations

(ramble on here)
Suggested viewing

Sal Kahn – TED Talk: “Let’s teach for mastery – not test scores”
Thank you. Questions?

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