Whole Hog Mastery Teaching and Learning

in an Introductory Statistics Classroom

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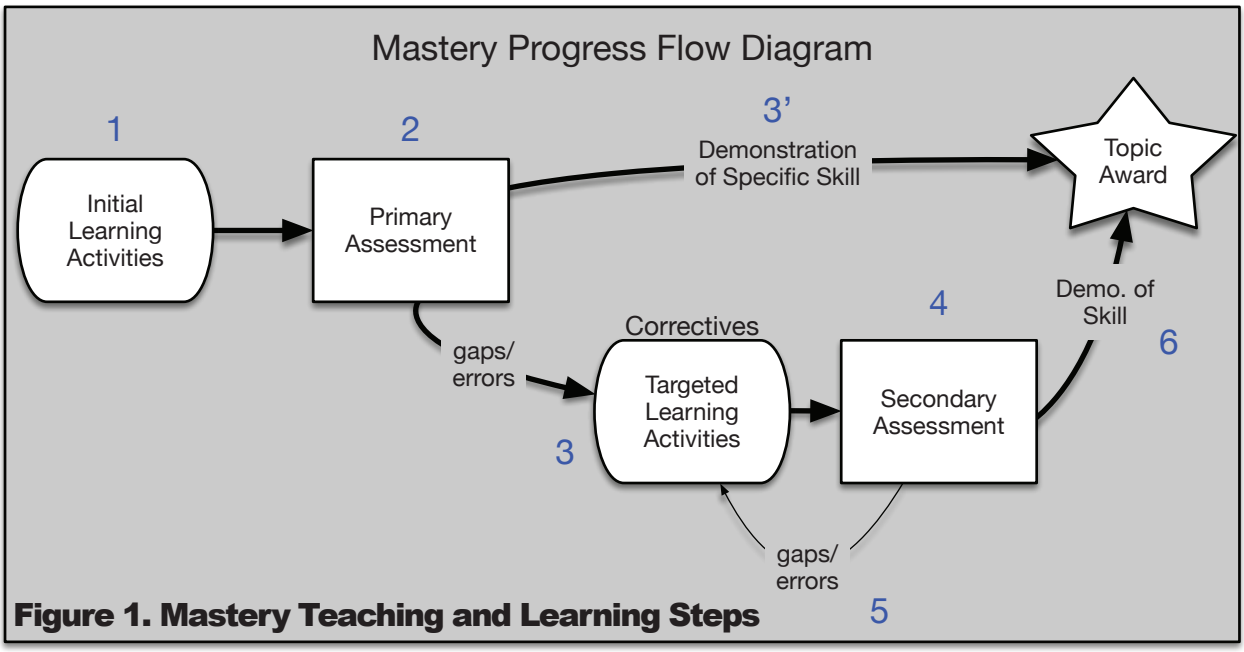

Figure 1. Mastery Teaching and Learning Steps

Figure Legend

1. Students engage lessons on a learning outcome (LO).

2. An open-ended assessment on the LO is issued.

3'. Students demonstrating basic proficiency obtain an award (a.k.a. badge) for the LO. They move on to the next topic.

3. Students evidencing important gaps or misconceptions are issued tailored learning activities (correctives) to address specific misconceptions.

4. An open-ended assessment on the LO is issued.

5. Further gaps or misconceptions are identified and new correctives issued. Step 4 is repeated.

6. Students demonstrate basic proficiency on the LO and earn an award.

Introduction

This submission addresses the application of mastery teaching and learning (MTL) in midsize (25-35 students) undergraduate classrooms.

The motivation for using MTL is anchored in a broad body of literature developed in various settings. There is evidence of large improvements in student performance with the use of MTL.[1–4]

MTL is an approach outlined by Benjamin Bloom.[2, 3] Figure 1 outlines the steps of the MTL approach used in an introductory statistics course for science majors and non-majors at California State University, Fullerton.

Assessment

No points are issued during the semester for activities or assessments. The assessments are open-ended and address conceptual understanding, application, and basic mechanics related to each topic. They are scored as pass or no pass. Performance, as measured by grades, is aligned with mastery as measured by the assessments. Students have reported shifting their orientation from optimizing grade performance to optimizing learning, which is particularly relevant for students not committing to obtain an A.

Mastery is evaluated at a moderate granularity of topics. Generally, there are 1-4 assessed topics per chapter. Example topics are included in Table 1.

During periods where students are working on correctives, other students can be provided curriculum on more advanced or specialized data science-related skills. Examples:

statistical programming,
complex data visualization.

Key Challenge

Workload. A major challenge for MTL is ensuring the workload is feasible for the instructor and determining appropriate semester-end grading criteria. Increasing the granularity of the topics is limited by the instructor's capacity to process the assessments and build correctives.

Potential Key Benefit

Increased competency. Students that get tripped up on foundational topics are quickly noticed and supported. Because concepts in introductory statistics are highly nested and interrelated, this can make it easier for students to be successful when addressing subsequent material.

Collaborations Sought

Shared efforts to develop, pilot, and evaluate mastery components in introductory statistics courses.

Generation of topic delineations.

Generation of guidelines for assigning grade levels to each topic. Which topics should be mastered to pass the course? Which topics should be mastered to get at least a B?

References

1. Winget M, Persky AM. A Practical Review of Mastery Learning. Am J Pharm Educ. 20228906.

2. Bloom B. The 2 Sigma Problem: The Search for Methods of Group Instruction as Effective as One-to-one Tutoring. Educational Researcher. 1984;13:4-16.

3. Guskey TR. Closing achievement gaps: revisiting Benjamin S. Bloom's "Learning for Mastery". Journal of advanced academics. 2007;19:8-31.

4. Kulik C-LC, Kulik JA, Bangert-Drowns RL. Effectiveness of mastery learning programs: A meta-analysis. Review of educational research. 1990;60:265-299.

Table 1. Example topics assessed for mastery.

Describing Distributions: Numerical
- Measures of Center (i,u,c,a)
- Measures of Variation (i,u,c,a)
- Percentiles (i,u,c,a)
- Outliers (i,u,c,a)
- SUMS (i, c)

Describing Distributions: Graphical
- *Univariate Graphs (i,u,c,a)*
- Bivariate Displays (i,u,c,a)
- 3 Way Graphs (i,u,c,a)

Measurement
- True Score Theory (i,u,c)
- Consequences of measurement error (i,u,a)

Observational Studies
- Definition and Structure (i)
- Sampling & Sampling Frames (i,u,a)
- Sampling Designs (i,u,a)
- Longitudinal Studies (i,u,a)
- Interpret Obs. Studies (i,u,a)

Experiments
- Definition and Structure (i)
- Randomization (i,u,c,a)
- Interpret Exp. Results (i,u,a)

Measures of Association and Effect
- Correlation (i,u,c,a)
- Regression (i,u,c,a)
- Relative Risk, Mean Differences (i,u,c,a)
- Adjusted Differences (i,u,a)

Probability
- Basic Probability (i,c)
- Relational Probability (i,c)
- Test Accuracy (i,u,c,a)
- Bayes Theorem (i,u,c,a)

Probability Distributions
- Binomial Distribution (i,u,a)
- Normal Distribution (i,u,c,a)

Sampling Distributions
- Properties (i,u,c)
- Law of Large Numbers (i,u,a)
- Central Limit Theorem (i,u,a)

Estimation
- Margin of Error/Confidence Intervals (i,u,c,a)
- Factors Impacting Accuracy and Precision (i,u,a)

Statistical Hypothesis Testing (NHST)
- Reasoning Behind NHST (i,u,a)
- *Relation Between Research Hypotheses and Statistical Hypotheses (i,u,c,a)*
- Criticism of NHST (i,a)
- *Accepting the Null (i,u,a)*
- Conditions for Inference (i,u,a)
- *Appropriate Usage/Abuse of the Term "Significant" (i,u,a)*
- Responding to violation of model assumptions (i,u,a)

Example NHSTs
- NHST for a Mean with Known S.D. (i,u,c,a)
- Inference for a Sample Mean
- *Comparing Two Means (i,u,c,a)*
- Regression Inference (i,u,c,a)
- Chi-square test (i,u,c,a)

Causal Inference
- Approaches to causal evidence (u, a)

Communication: Integrating Statistical Findings
- *Write Brief Description of Findings: Summary Statistics (i,a)*
- *Analyze and revise a news article on a public health topic*
- *Write Brief Description of Findings: Inferential Statistics (i,a)*
- *Develop research question and write up a basic research/analysis plan (synthesis)*

Execution, Analysis, Statistical Concepts
- *Match scientific hypotheses/models to statistical hypotheses/models (i,a)*
- *Interpret practical meaning of statistical findings (u, a)*
- *Import, Create, Manipulate Data Files (a)*
- *Trouble-shoot software and use software reference material (a)*
- State the benefits of statistics to PH researchers and practitioner *(i,u)*
- *Multiple-Regression (i,u,c,a)*
- Interactions *(i,a)*

i = identify, c = compute, u = understand/explain, a = apply