

Online Mastery-Style Homework in a Large Introductory Physics Class

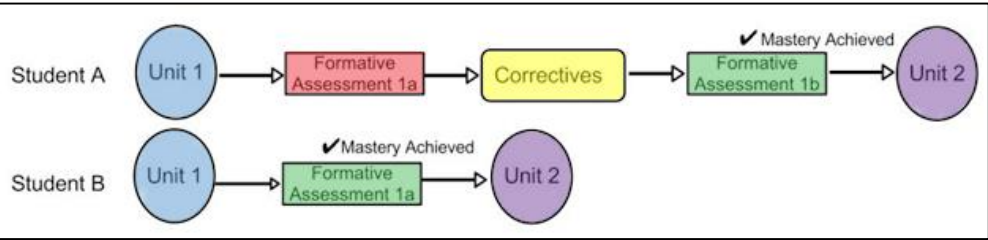
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Mastery Learning

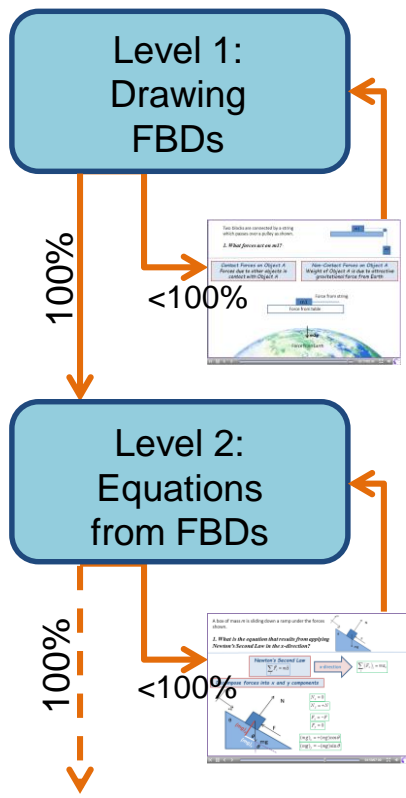
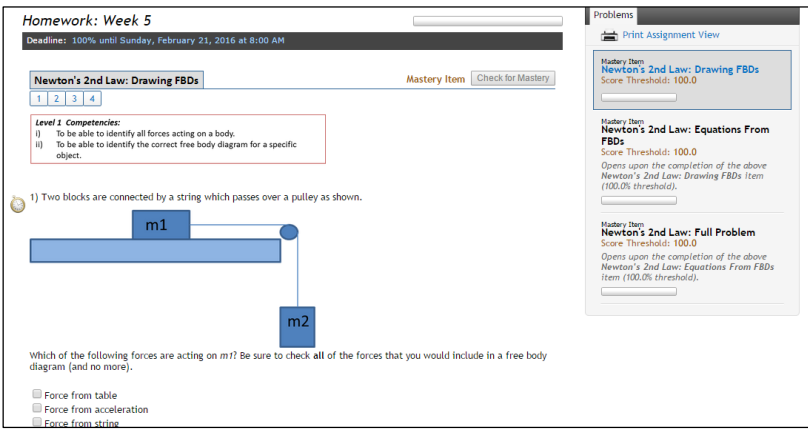
The popularization of mastery instruction is often attributed to Benjamin Bloom¹ and Fred Keller² for their 1968 papers. Both suggested teaching by breaking content into small, testable units. Students who demonstrate mastery of a unit achieve access to the next unit, while struggling students are provided correctives and allowed to re-test until they have also mastered the material. This system allows a group of diverse students to spend variable amounts of time on content and has been shown to improve achievement, retention, and attitudes in students across most disciplines.³



Experimental Materials

Mastery materials were delivered online using the SmartPhysics system. Students completed homework once per week, and each week had approximately four or five levels. Each level typically had four versions for students to cycle through, which tested the same skills but often had different surface features.

Correctives provided were narrated animated solution videos, showing the worked problem.



Over 500 problems and solution videos were created and used for the course during 8 weeks of homework.

Future Improvements

Information regarding student difficulty and frustration are being used to inform the next iteration of this homework for students in fall '15. Some changes include:

Math Levels

Each week will have an associated level showing the dominant math skill used in that week's homework, both in a math context and a physics context, explicitly connected. Included so far are coordinate geometry, vectors, vectors in rotated coordinates, systems of equations, and algebraic manipulation.

New Delivery Method

To counter skipping, students will only have four attempts to try a level, but will receive partial credit even if they do not master it.

Ability to Move On

Students will be able to move on to the next level if they are willing to forfeit their missing points. This is intended to give students more agency and hopefully reduce resentment and encourage ownership of their learning.

Two Assignments per Week

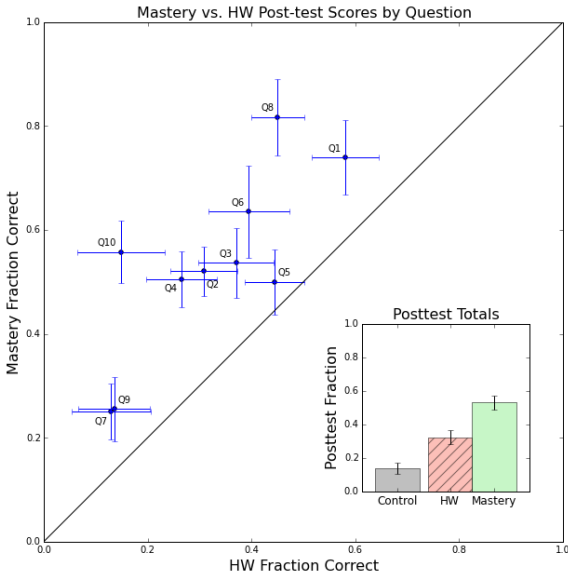
Instead of students completing all their homework for one day, the assignments will be broken in half and due on two separate days, to help students manage their time and avoid frustration.

Address Affect Directly

The beginning of the term will involve TAs and students having open discussion about mastery's pros and cons and how to use it effectively.

Previous Work and Goals

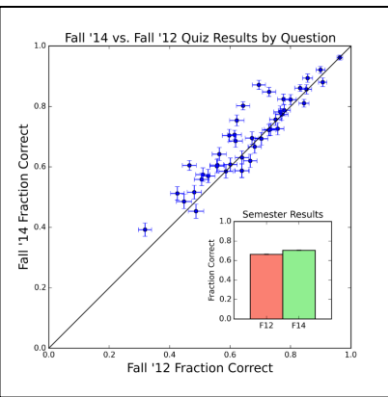
During a clinical study, students using mastery materials significantly outperformed students using UIUC traditional style online homework when taking the same post-test. For more details, see poster by Noah Schroeder.



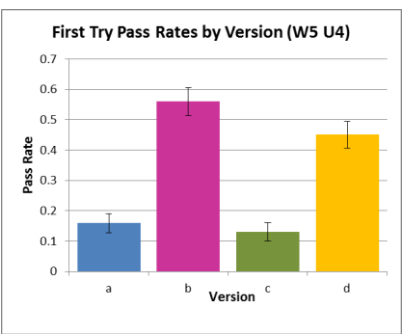
From success in a controlled environment, the next goal was to implement mastery style homework for a large semester-long class.

Results & Conclusions: Achievement

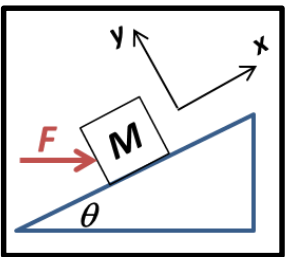
Students during fall '14 (mastery semester) performed better on some online quiz questions than previous years' students, but overall showed very slight achievement increase. This is shown on the right.



Data reveals, additionally, which questions were more difficult for students than anticipated. Below are two examples.



Versions A and C required students to use rotated coordinates (ramps) while B and D were traditionally oriented. The difference in difficulty between these was larger than expected.



- ✓ 1. Choose FBD.
- ✓ 2. Write down x-coordinate equation of motion ($F=ma$).
- ✓ 3. Write down y-coordinate equation of motion ($F=ma$).
- ✗ 4. Solve for acceleration.

Of students who were able to write down equations of motion, only 40% could solve for acceleration. This suggests they may need help with systems of equations or may not realize that they should use this skill.

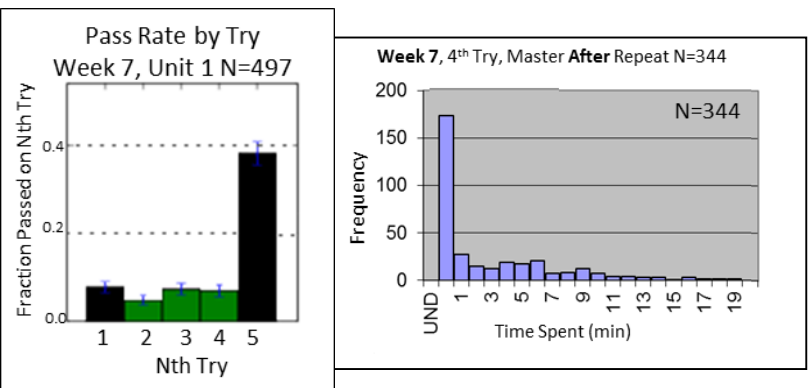
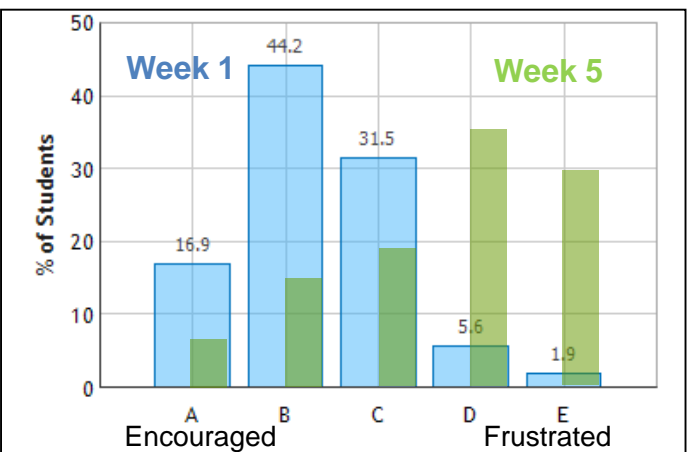
Experimental Group

Online mastery homework was implemented in Physics 100, a preparatory class for UIUC's calculus based introductory physics sequence, aimed at students who feel unprepared for the courses, often due to diversity in high school physics background. The class is mostly first-term freshmen and had about 500 students.

The course covers kinematics and dynamics, the first third of the calculus based mechanics course.

Results & Conclusions: Behavior & Affect

Students became frustrated and began circumventing the mastery process by "skipping," shown in the bottom right. Because there were only four versions, students began to copy down answers from the first version and cycle until they reached the same version, spending little time on sincere attempts.



Additionally, the data showed that a very small fraction of students used the solution videos.

More information



For more information, please visit: <http://go.illinois.edu/GutmannPER>

1 - B. Bloom, Eval. Comment 1, 12 (1968).
2 - F.S. Keller, J. Appl. Behav. Anal. 1, 79 (1968).
3 - C.-L.C. Kulik, J.A. Kulik, and R.L. Bangert-Drowns, Rev. Educ. Res. 60, 265 (1990).

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