



# Effective use of interactive physics simulations for pre-class assignments

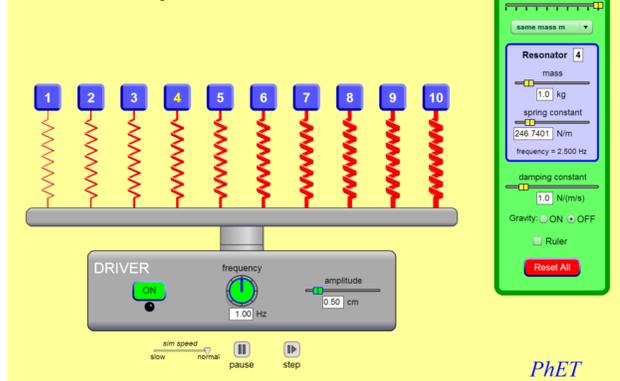
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Thanks also to Andrzej Kotlicki and Don Witt



## Introduction

- Pre-reading—brief, focussed reading assignments with quizzes—prepare students for active classes<sup>1</sup>
- PhETs are interactive computer simulations that aid physics instruction<sup>2</sup>
- Students learn best with PhETs with question-driven scaffolding<sup>3</sup>

### PhET example: Resonance



Study design

Start of semester

Trial week for each topic

1-2 days later

### Online quiz

on all three topics  
(black-body radiation,  
masses & springs;  
resonance)

“Prescore”

### Study conditions:

Students complete  
pre-reading using

**Textbook only**  
or  
**PhET then Textbook**  
or  
**Textbook then PhET**

### Before class:

Online quiz:  
identical to  
pre-test items;  
Survey items

“Postscore”

### In class:

Clickers: Application  
questions after  
instruction

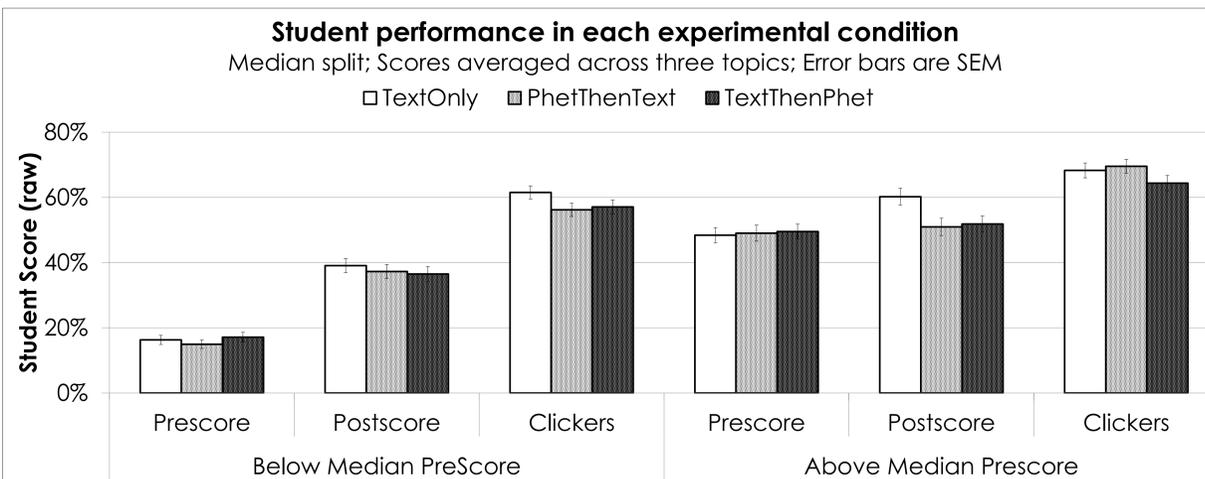
“Clickers”

Repeat for 2 other topics,  
swapping conditions for  
each group of students

## Research questions

1. Can the use of inquiry-oriented PhET-based pre-class activities (in addition to textbook reading) improve the preparation of students for in-class learning?
  - Does it depend on the order of activities?
2. Can the use of inquiry-oriented PhET-based pre-class activities improve the attitudes of students towards the assignments and material?

Learning results



- Learning did occur between the pre-test (pre = 32.5 ± 1%) and the post-test (post = 40.9 ± 1%);  $t(752) = 5.79$ ,  $p < 0.0001$ . (For students who completed all three topics)

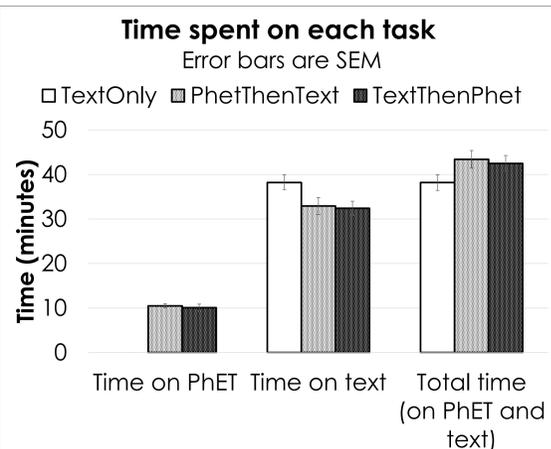
- Used a generalized linear mixed model to predict success on each postscore item  $j$ :

$$\text{Log\_odds}(\text{Postscore\_success}_{ijkl}) = \beta_0 + \beta_{1j} \times \text{Prescore}_j + \beta_{2k} \times \text{Topic}_k + \beta_{3l} \times \text{Condition}_l + \beta_{4kl} \times \text{Topic}_k \text{Condition}_l + \varepsilon_l$$

A non-zero  $\beta_{3l}$  would indicate an effect of condition; non-zero  $\beta_{4kl}$  would indicate a mixed effect.

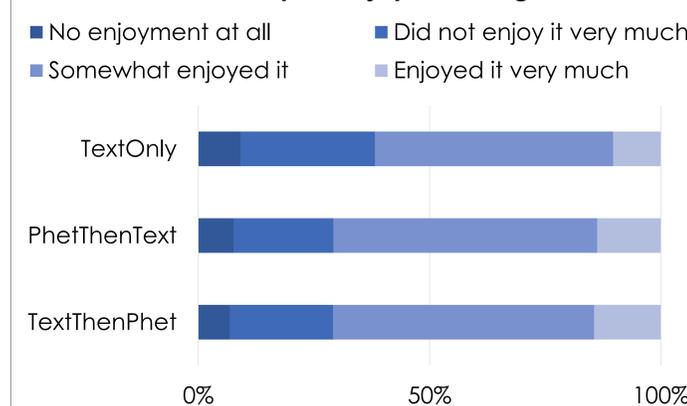
- There was no significant effect due to condition, when controlling for pre-score and topic:  $p(\beta_{3l}), p(\beta_{4kl}) > 0.1$ .

Survey results



- Students spend marginally more time overall when the PhET assignment is included:  
 $\text{time}_{\text{Text}} = 38.2 \pm 1.7 \text{ min}$   
 $\text{time}_{\text{PhETThenText}} = 43.4 \pm 2.0 \text{ min}$   
 $\text{time}_{\text{TextThenPhET}} = 42.5 \pm 1.8 \text{ min}$
- More students in the PhET conditions said they enjoyed the pre-class assignment (either “Somewhat enjoyed it” or “enjoyed it very much”): 71% of respondents versus 62%.

### How much did you enjoy this assignment?



## Summary

- Learning occurred during the assignment (from pre-test to post-test)
- Controlling for pre-score and topic, there was **no** significant effect due to condition (including PhET or not)
- Students spent marginally more time on the assignments with PhETs, and reported enjoying them more.

Further analysis is ongoing.

<sup>1</sup>Heiner, Cynthia E., Amanda I. Banet, and Carl Wieman. American Journal of Physics 82.10 (2014): 989-996.

<sup>2</sup>Wieman, Carl E., Wendy K. Adams, and Katherine K. Perkins. Science 322.5902 (2008): 682-683.

<sup>3</sup>Adams, Wendy, Zachary Armstrong, and Cynthia Galovich. 2015 PERC Proceedings.