

Scientific Practices in Introductory Physics Labs

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Why Transform Labs?

PROCEEDINGS

THE AMERICAN ASSOCIATION

FOR THE

ADVANCEMENT OF SCIENCE,

TWENTY-SIXTH MEETING,

Held at

Boston, Mass.,

AUGUST, 1881.

SALEM;
PUBLISHED BY THE PERMANENT SECRETARY.
1881.

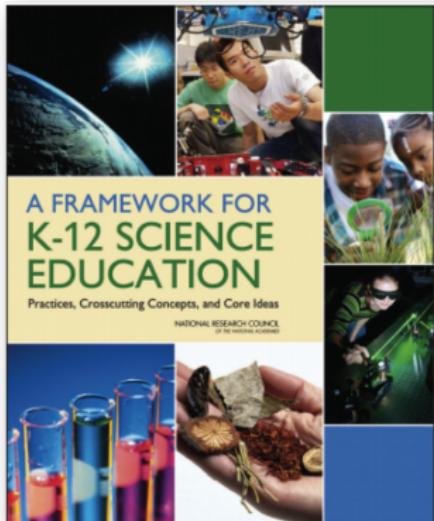
Need Science Practices

"[Typical courses in t]he sciences . . . are **not** made the means of cultivating the *observing powers*, stimulating *inquiry*, exercising the judgment in *weighing evidence*, nor of forming independent habits of thought." [Emphasis mine]

AAAS (1881)



Why Transform Labs?



Meaningful Science

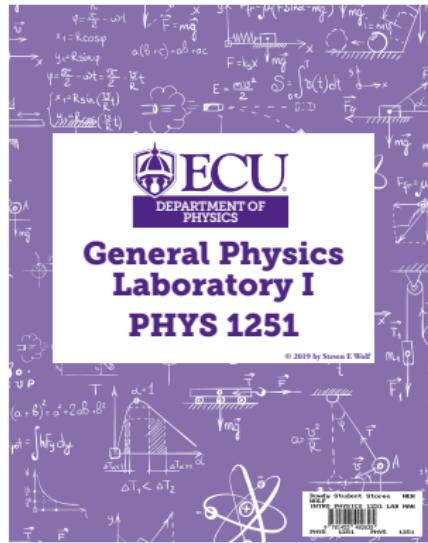
"To support students' meaningful learning in science, [practices and content] need to be integrated into standards, curriculum, instruction, and **assessment**."

NRC framework for science education (2012) (emphasis mine)

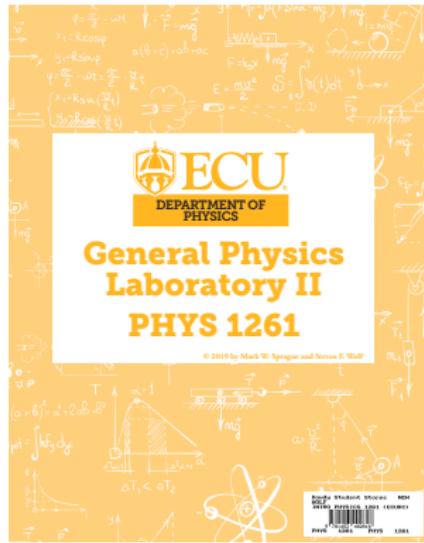
NRC (2012)



Science Practice Focused Lab curriculum



Piloted Spring 2018



Piloted Fall 2018



What science practices?

M.J. Ford, *Science Education* **99**, 1041 (2015).

Empirical practices:

- EP1 Locate information relevant to a scientific problem.
- EP2 Construct a relevant/appropriate scientific question for a given problem.
- EP3 Design an experiment to test a scientific question.
- EP4 Apply (or know when to apply) appropriate analytical methods to examine a scientific problem.
- EP5 Appraise an experimental design to identify elements and limitations and how they impact scientific findings/conclusions.
- EP6 Troubleshoot technical issues.
- EP7 Evaluate evidence and critique experimental designs.
- EP8 Interpret basic statistics (e.g., average and SD).

What science practices?

M.J. Ford, *Science Education* **99**, 1041 (2015).

Representative practices:

- RP1 Generate a hypothesis or make a prediction based on a scientific model.
- RP2 Construct an argument based on evidence.
- RP3 Identify additional information needed to support an argument.
- RP4 Provide alternative explanations for results that may have many causes.
- RP5 Integrate and apply knowledge across sub-disciplines.
- RP6 Represent data in a visual form.
- RP7 Interpret visual representations of data.
- RP8 Construct a Data table.
- RP9 Data Analysis.

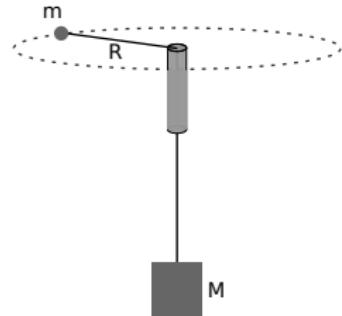
Practical design – Physics I

Prompt

You notice that for a given rotation radius R , the stopper (mass m) travels faster as the hanging mass M increases. You want to determine the relationship between hanging mass (M) and period (T) for a given radius (R).

Students turn in a report that includes:

- ① An experimental procedure
- ② A data table
- ③ Their claim
- ④ A (transformed) plot of T vs. M
- ⑤ An argument



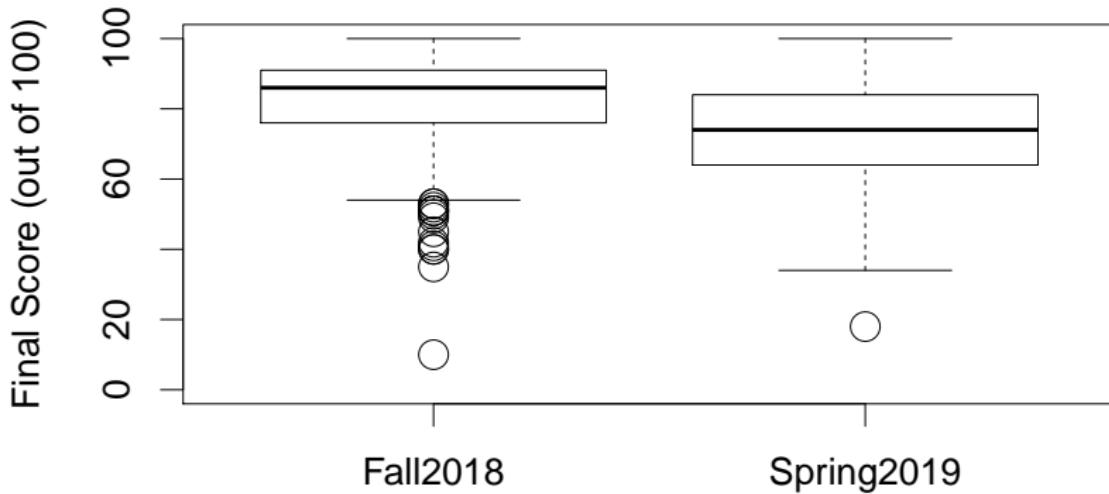
Exam security measures

- This practical is to be given throughout the entire grant period.
- Crafted a detailed rubric.
- Exams are turned in online and sent through SafeAssign/TurnItIn.

Faculty were concerned that the exam would get out/students would cheat. That informed our initial analysis.



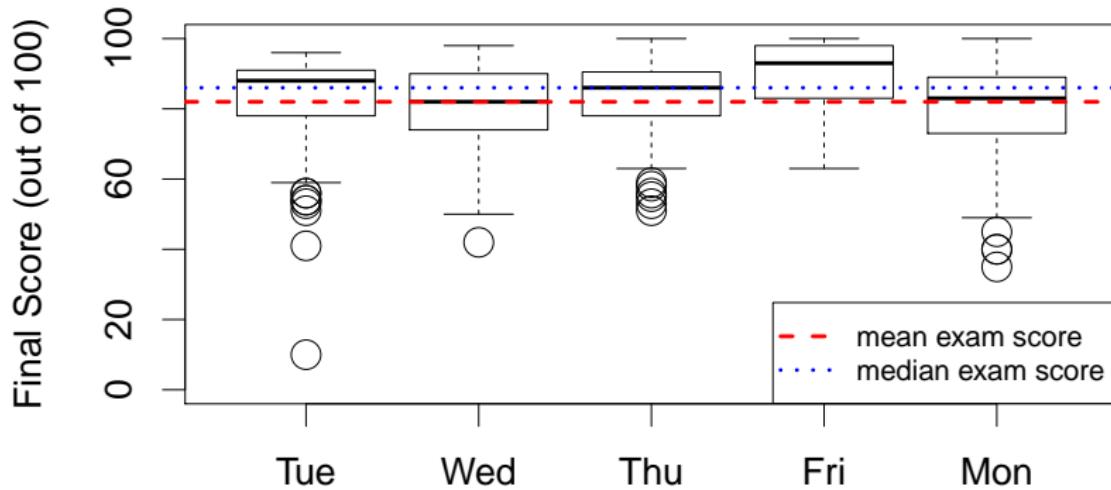
Preliminary Results: Across semesters



Fall 2018 semester ($\bar{x} = 82, s = 12$) and the spring 2019 semester ($\bar{x} = 73, s = 15$); $t(674.22) = 9.197, p < 0.001$.



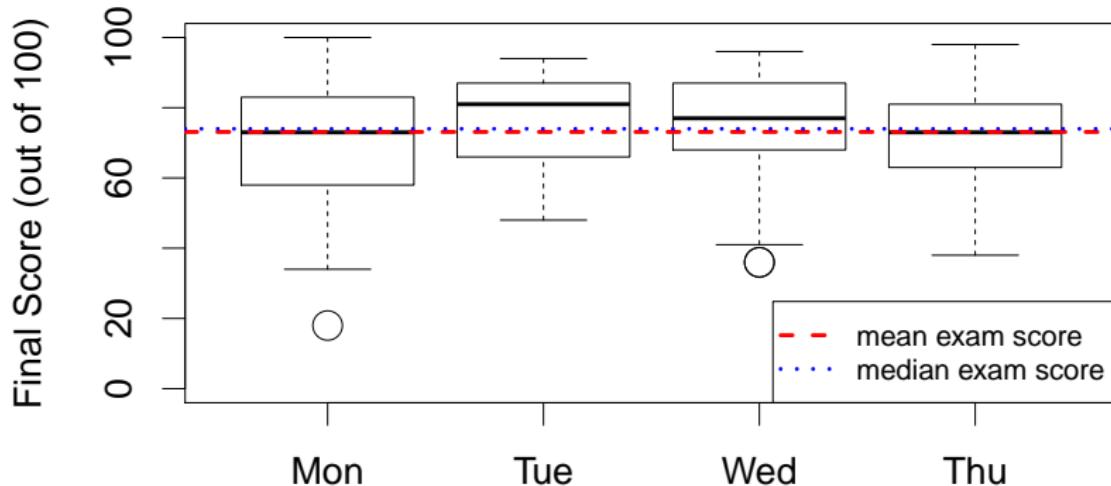
Preliminary Results: Across days (Fall 2018)



No significant difference based on day: $[F(3, 462) = 2.18, p = 0.008]$
(Friday removed).



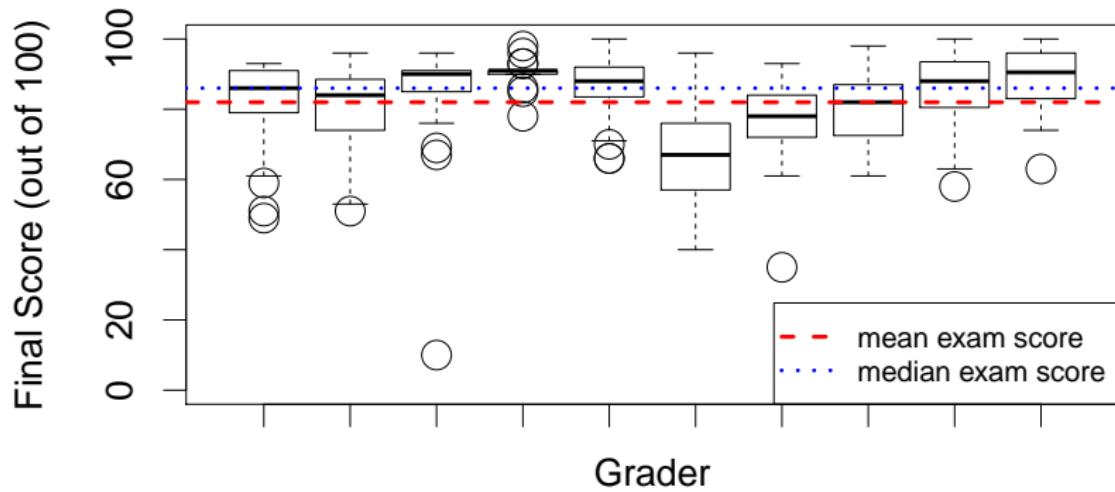
Preliminary Results: Across days (Spring 2019)



Exam day was significant: $[F(3, 354) = 2.908, p < 0.035]$. However, absolute difference in means was 6% on Tuesday and 5% on Wednesday.



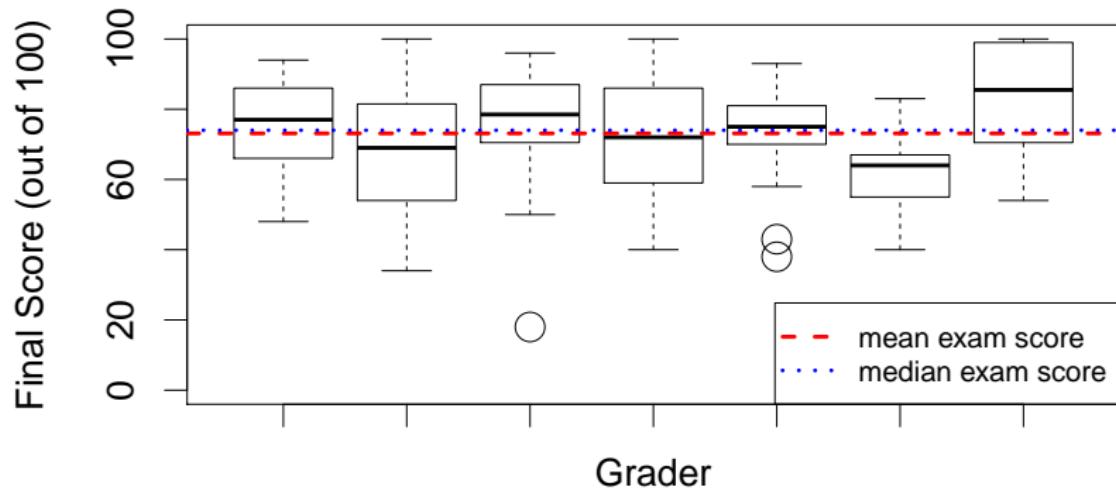
Preliminary Results: Across graders (Fall 2018)



Grader was a significant source of variation: $[F(9, 488) = 22.69, p < 0.001]$



Preliminary Results: Across graders (Spring 2019)



Grader was a significant source of variation: $[F(6, 351) = 6.514, p < 0.001]$



Conclusions/Future Directions

- We have developed a practical with face validity
- We are able to use it on multiple days and across semesters without issues with cheating
- We are working on calibrating graders
- We are working on establishing construct validity



XLABs Personnel

Biology

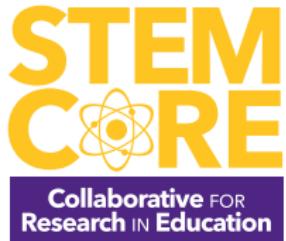
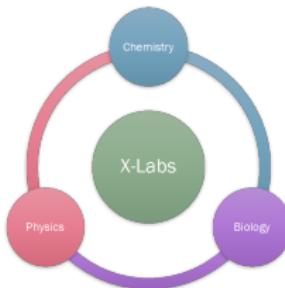
- Co-PI: Heather Vance-Chalcraft
- Co-PI: Kristine Callis-Duehl
- Taria Crenshaw

Physics

- Co-PI: Steven Wolf
- Mark Sprague
- Robert Seip
- Heather Hundley

Chemistry

- Project Lead: Joi Walker
- Rosa Bell
- Feng Li
- Annalisa Smith-Joyner
- Kate Hosbein



Award # 1725655

Link to slides:



<http://bit.ly/ecuXLABs>



Thank You!

Any Questions?



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