Scientific Practices in Introductory Physics Labs

Steven F. Wolf, Mark W. Sprague

East Carolina University Department of Physics
STEM CoRE

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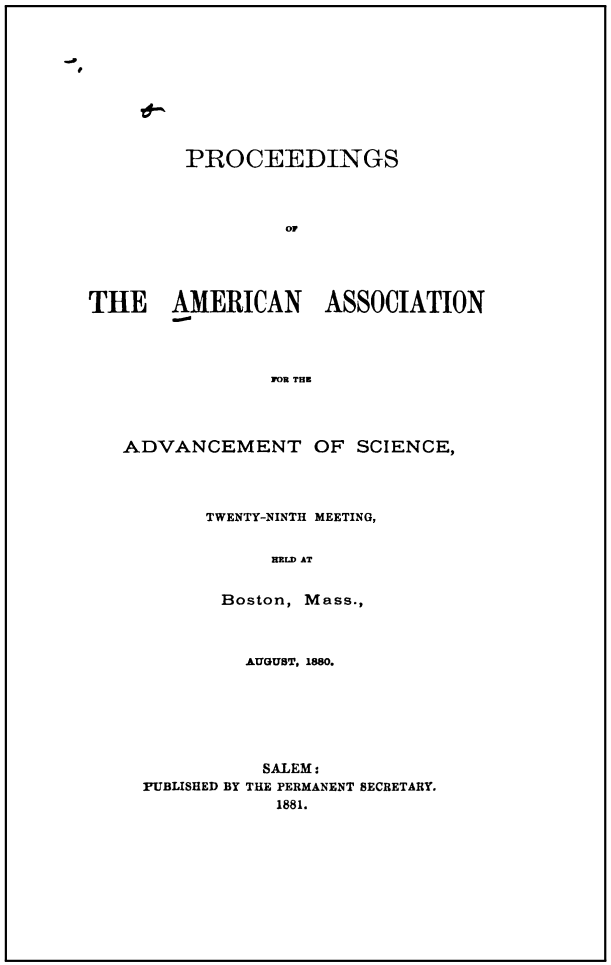
Why Transform Labs?



PROCEEDINGS

OF

THE AMERICAN ASSOCIATION

FOR THE

ADVANCEMENT OF SCIENCE,

TWENTY-NINTH MEETING,

HELD AT

Boston, Mass.,

AUGUST, 1880.

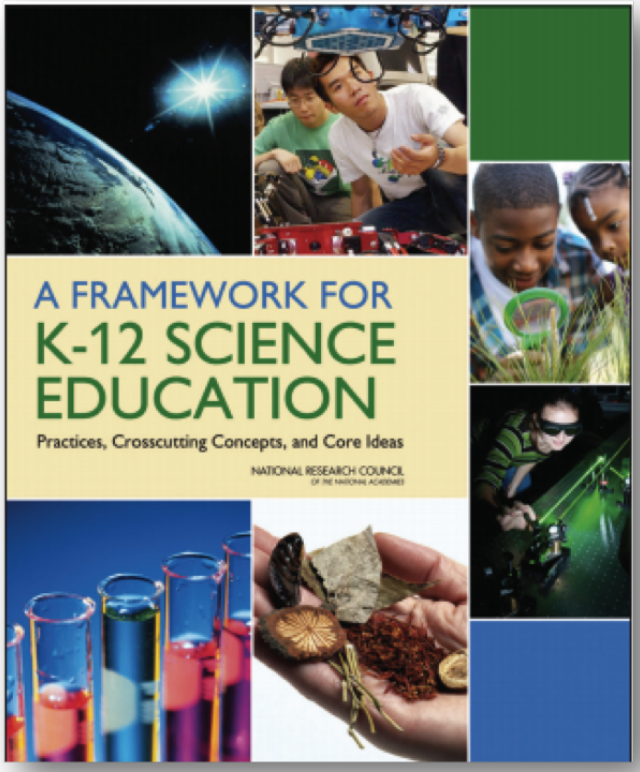
SALEM:
PUBLISHED BY THE PERMANENT SECRETARY.
1881.

AAAS (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]

Why Transform Labs?



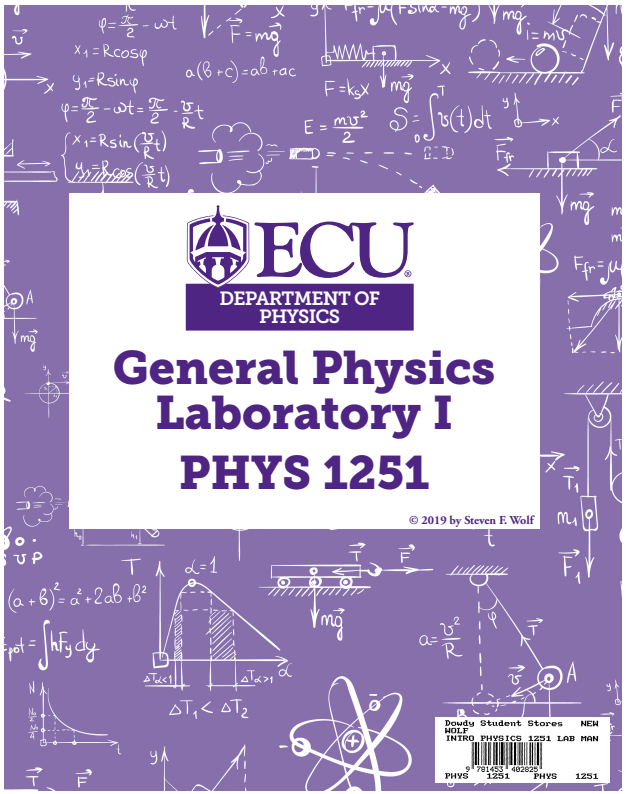
NRC (2012)

Meaningful Science

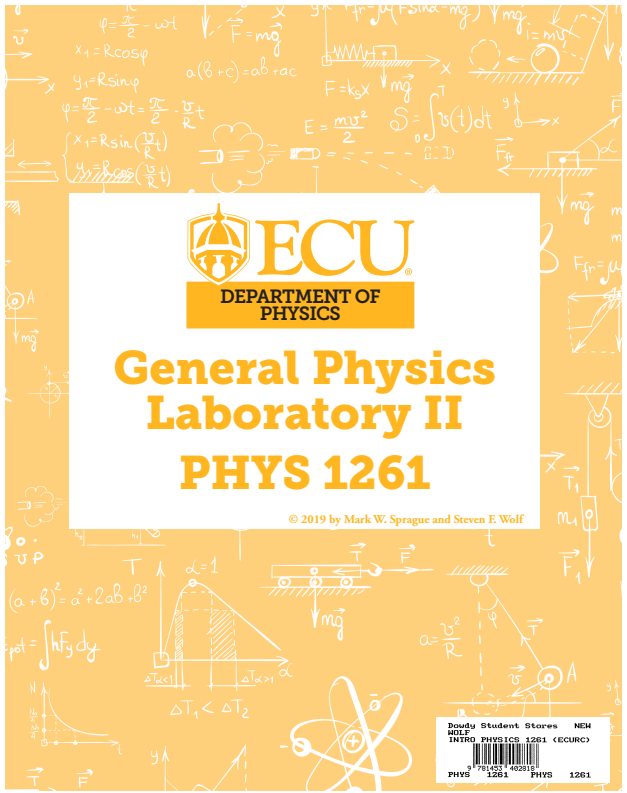
"To support students' meaningful learning in science, [practices and content] need to be integrated into standards, curriculum, instruction, and **assessment**."

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

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).

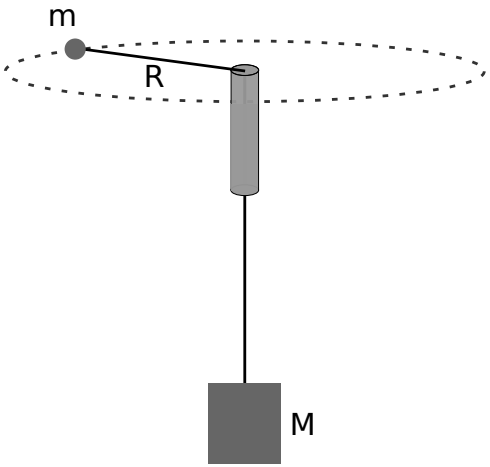
Representative practices:

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:

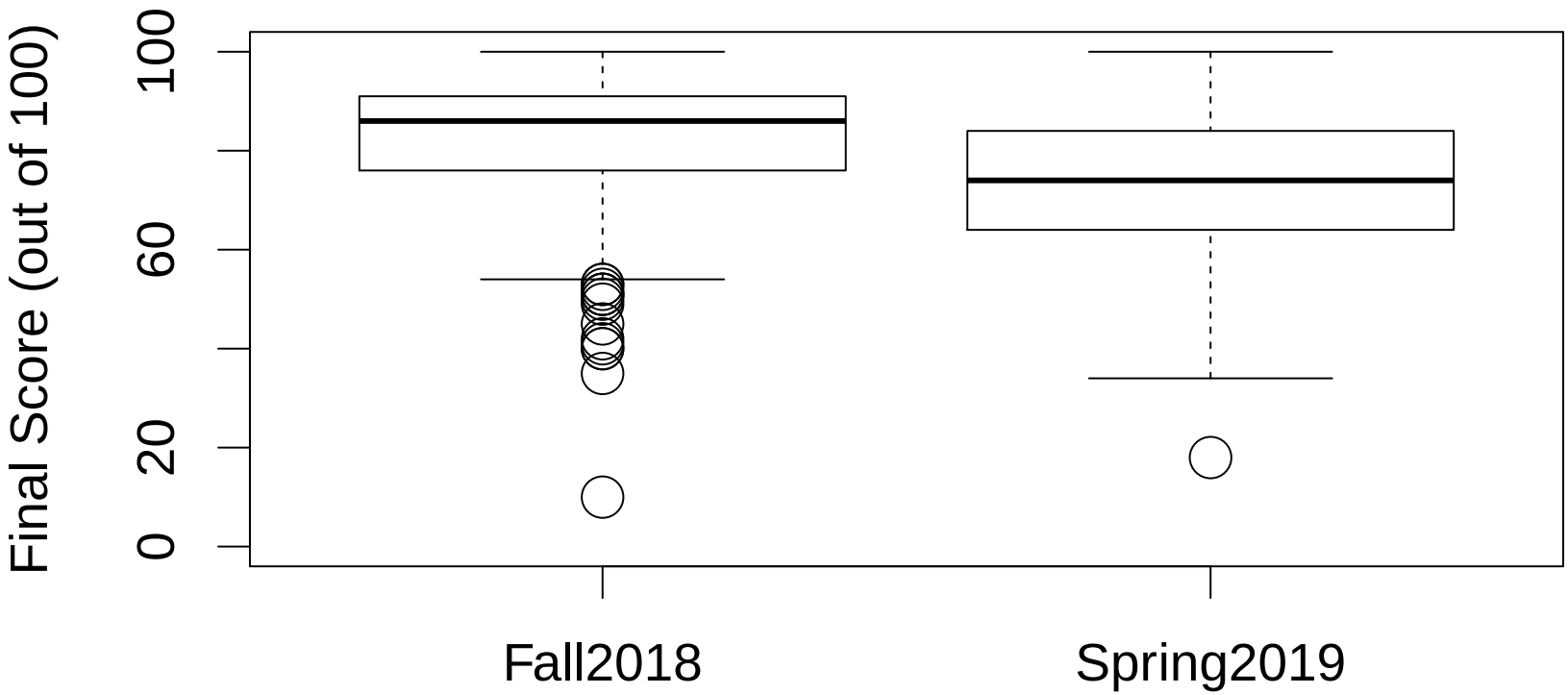
1. An experimental procedure
2. A data table
3. Their claim
4. A (transformed) plot of T vs. M
5. An argument

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.

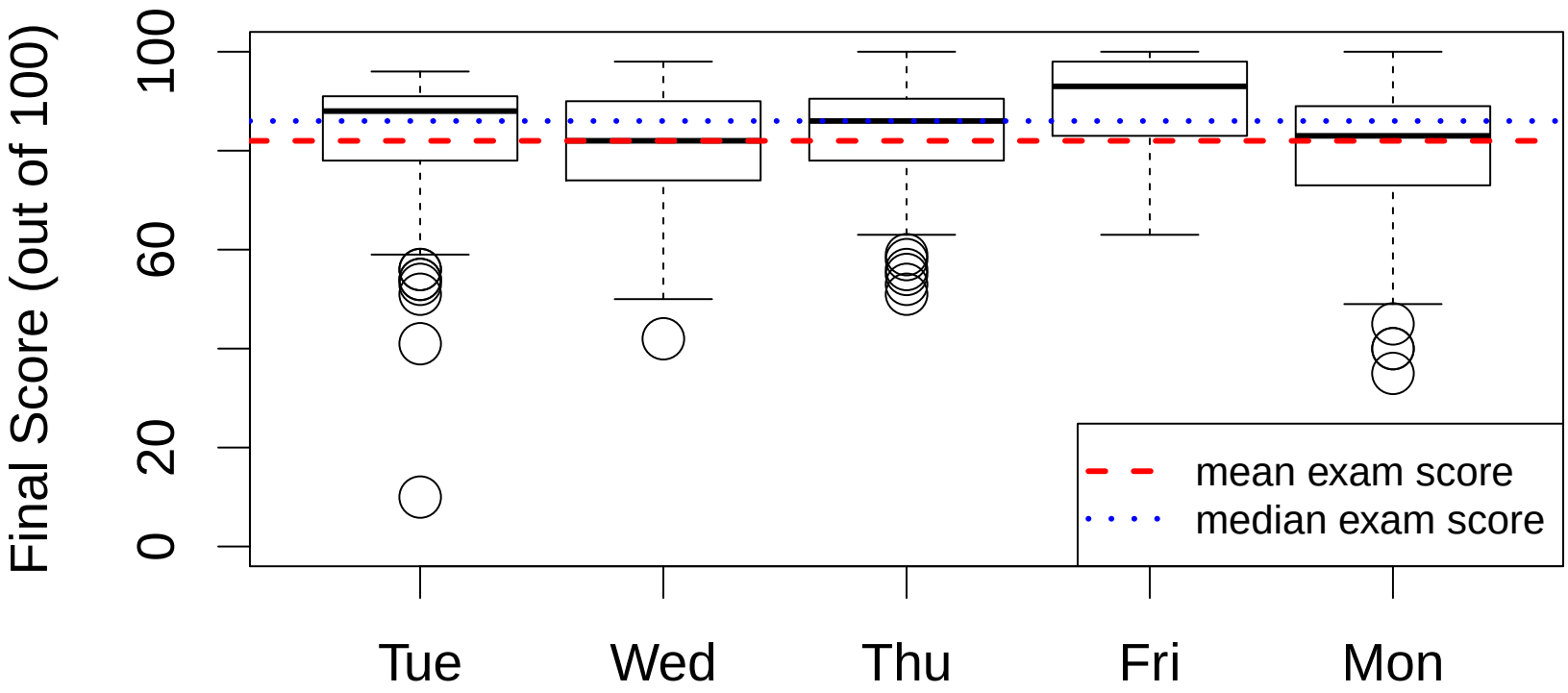
Faculty were concerned that the exam would get out/students would cheat. That informed our initial analysis.

Preliminary Results: Across semesters



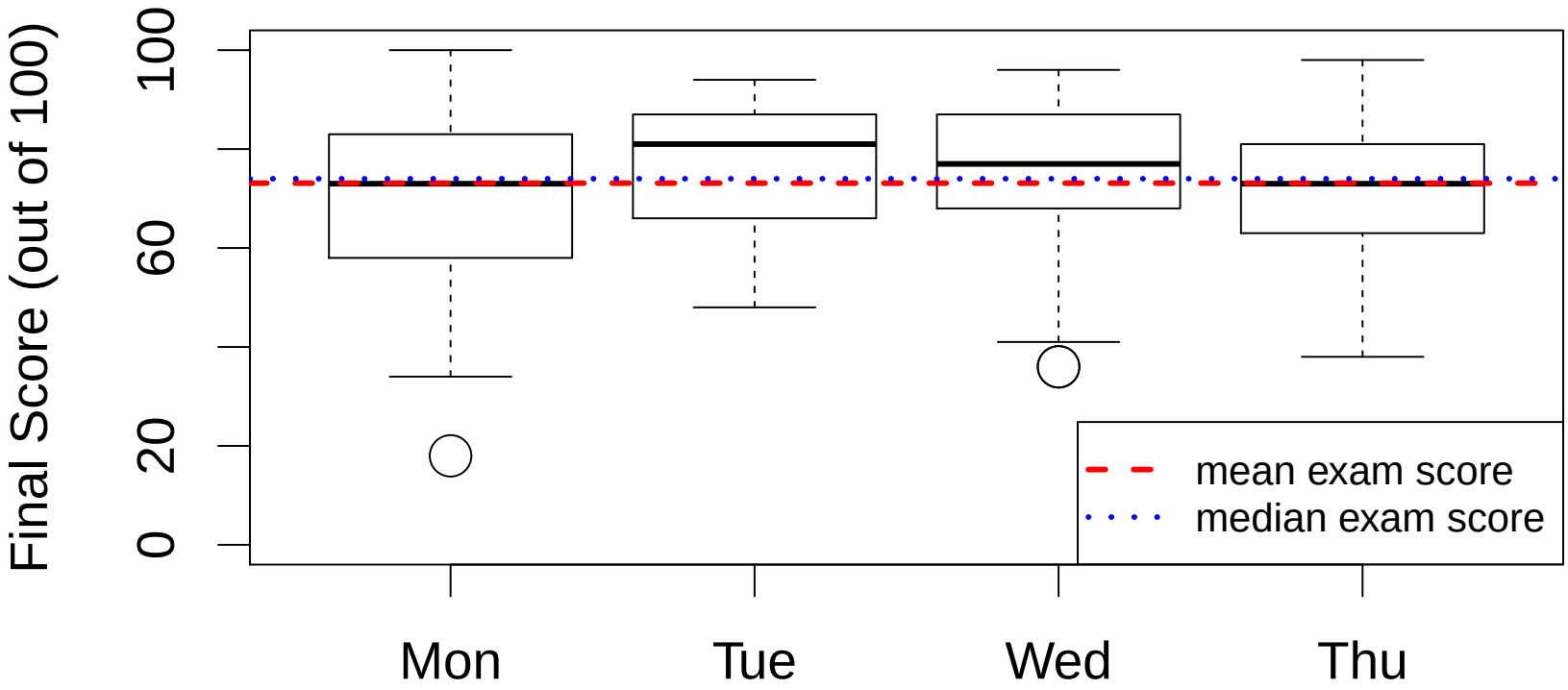
Fall 2018 semester ($\bar{x} = 82, s = 12$) and the spring 2019 semester ($\bar{x} = 73, s = 15$); $t(674.22) = 9.197, p < 0.001$.

Preliminary Results: Across days (Fall 2018)



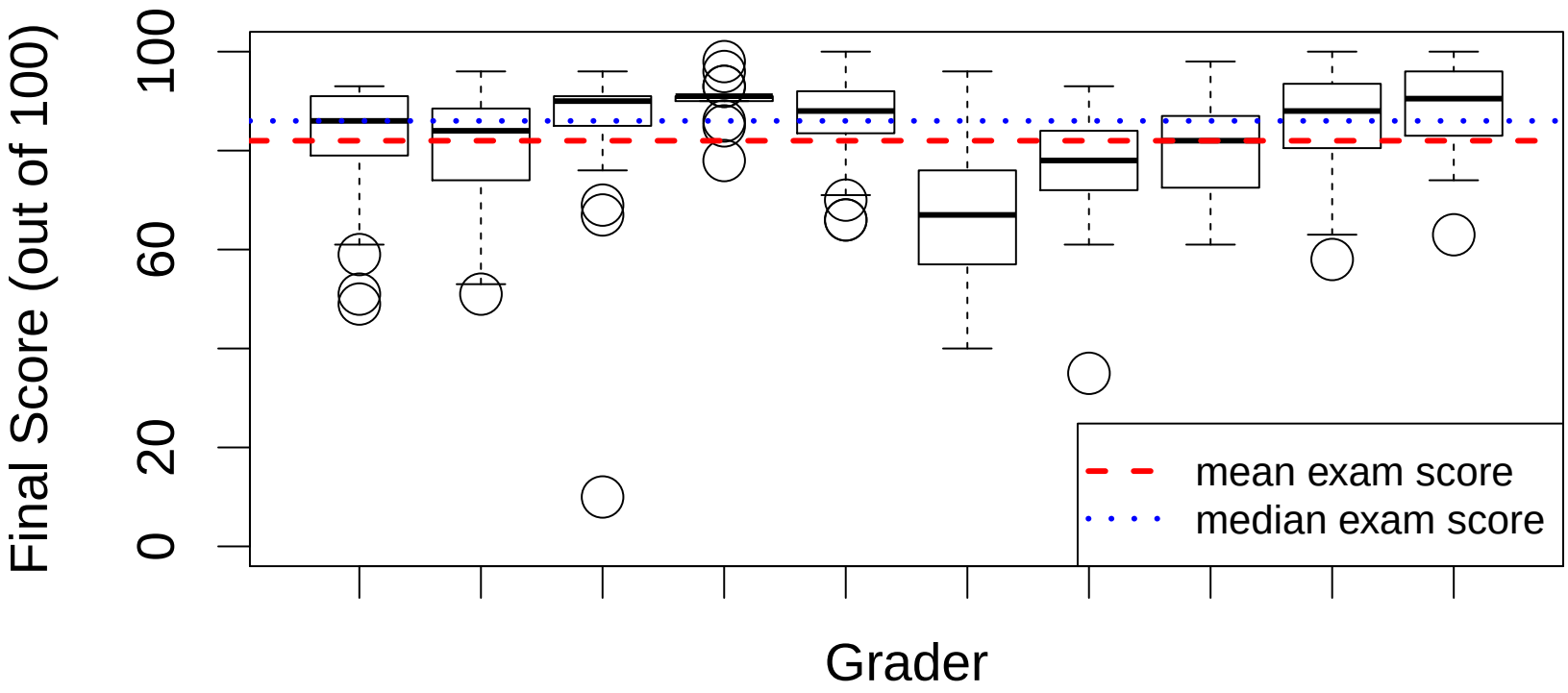
No significant difference based on day: $[F(3, 462) = 2.18, p = 0.008]$ (Friday removed).

Preliminary Results: Across days (Spring 2019)



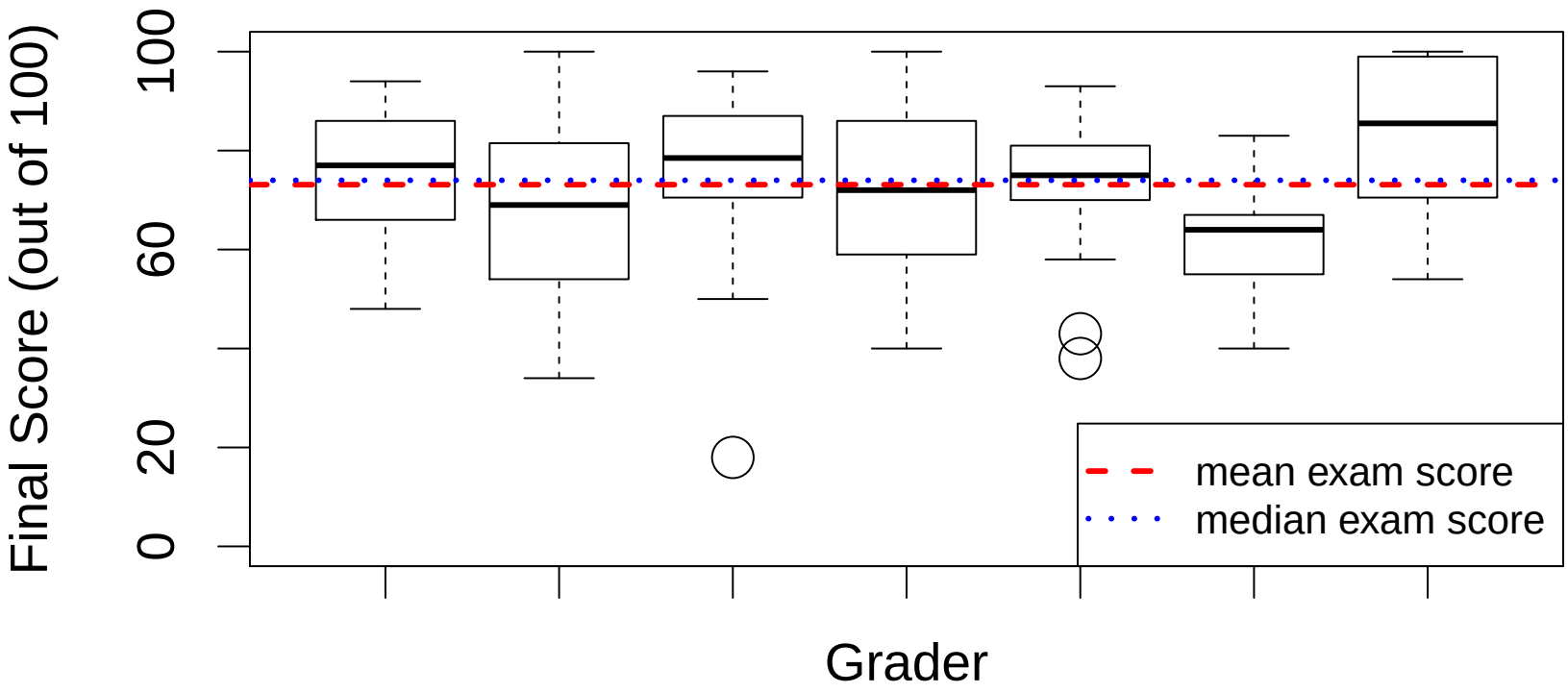
Exam day was significant: $[F(3, 354) = 2.908, p < 0.035]$. However, absolute difference in means was 6% on Tuesday and 5% on Wednesday.

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

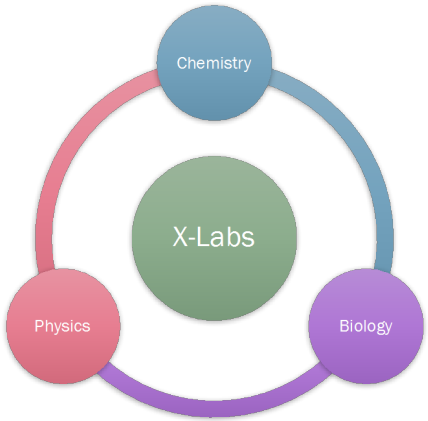
- Co-PI: Heather Vance-Chalcraft
- Co-PI: Kristine Callis-Duehl
- Taria Crenshaw

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



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Thank You!

Any Questions?

wolfs15@ecu.edu