Evaluation of Traditional Labs as Effective Content Delivery in a High-Enrollment IPLS Course.

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Two key studies suggested that completing labs based on a physics concept does not improve how well a student learns that concept, or reinforce conceptual content learned elsewhere.

Wieman and Holmes (2015) – no measurable difference on exam questions relating to lab topics, comparing students who took the labs and students who did not.

- Calculus based, physics and engineering students at Stanford.

Holmes et al (2017) - Nine different lab courses, designed to reinforce student understanding of physics content from other areas of the course, have been shown to provide no measurable added value to course performance.

- Three universities, nine Mechanics or E+M courses, calculus or algebra based, students from many science disciples

Why one more?

University of Guelph – First year IPLS Courses:

- High enrollment (and growing)
  - 5 courses annually, algebra-based
  - 4 with enrollment ~800 – 1000 – total students 4000+ annually

Why one more?

- Common lab design and in many cases common labs
  - Almost exclusively Life Science majors
  - Not presented as traditional Mechanics, E+M courses
  - Organized around Life Science topics

A different kind of course, and big student impact with any changes.

Is there a content reinforcement happening here that wasn't in previous work?

Setting: PHYS*1300 – Fundamentals of Physics – Fall 2017 semester

- ~900 students who did not take Grade 12 Physics in High School
- 5 labs over the course of the semester
  - Traditional “recipe” labs in scheduled lab periods
  - ~30 students per lab
- Course evaluation:
  - 10% lab completion
  - 50% quizzes in a mastery-based (multiple-attempt) system
  - 35% final exam

Study: Split into two treatments for lab 3 of 5:

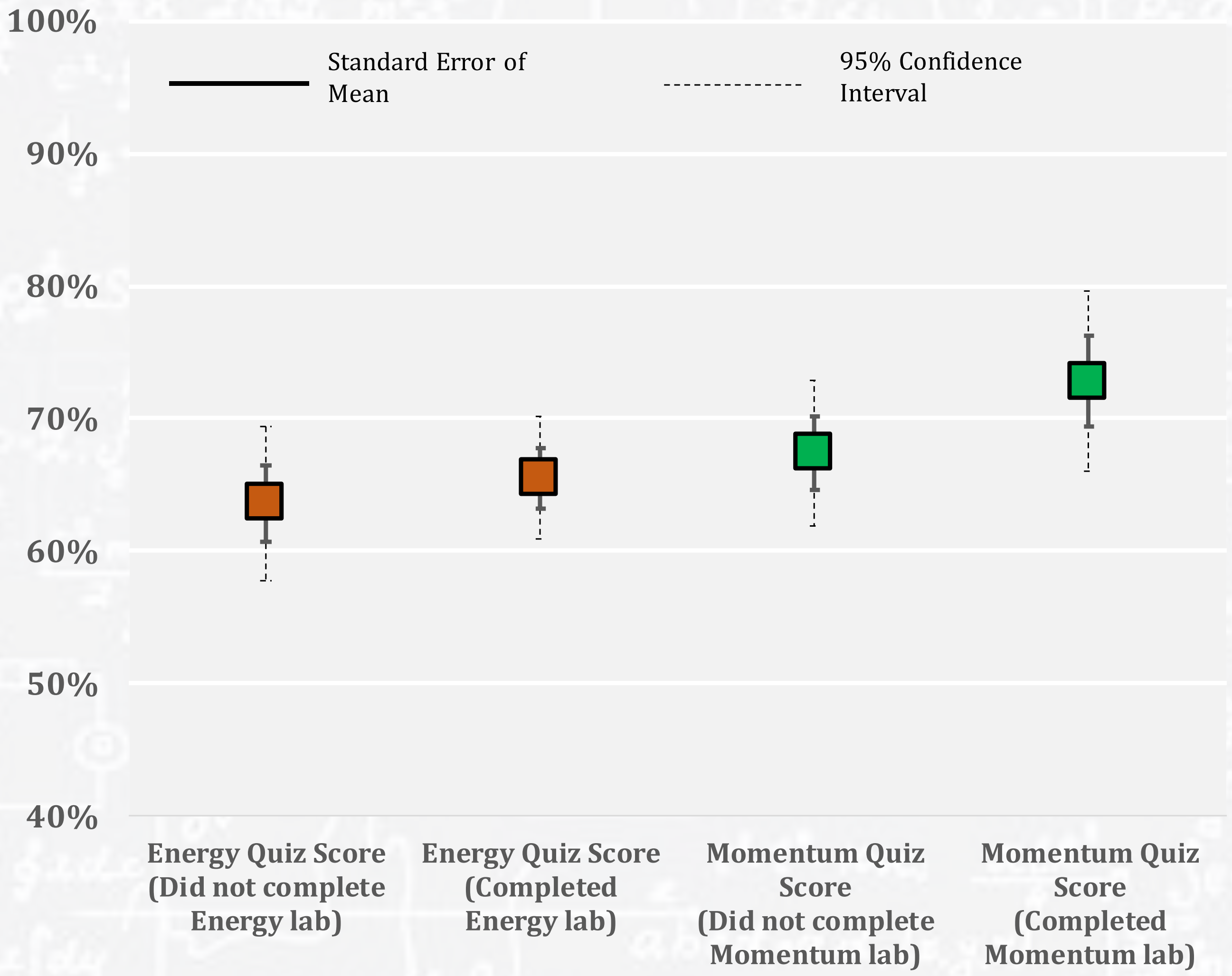
- Conservation of Energy **or** Conservation of Momentum

- Pre-, post-, and post-post-surveys including a "light" expert opinion survey modeled after E-CLASS
  - >90% survey participation
- In all, about 8% of final grade identified as being part of the total relevant course assessment:
  - 2 questions each on final exam relating to C of E, C of M
  - One full quiz relating to C of E, C of M

No significant difference on total relevant course assessment between students who did, or did not, complete a lab on that concept.

No significant difference on quiz questions between students who did, or did not, complete a lab on that concept.

(Taking retention time into account)



Students believe that lectures are significantly more helpful in learning course material than labs (or homework…)

Question	Mean Response [2]	Difference of mean response from mean lab experiments response [3]	Conclusions
The **homework assignments** in PHYS*1300 are helpful in learning and understanding the course material.	2.26	0.03 ‡	Students weakly agree that homework assignments are helpful in learning course material. There is no statistical difference between their agreement on homework assignments and laboratory experiments.
The **laboratory experiments** in PHYS*1300 are helpful in learning and understanding the course material.	2.23	---	Students weakly agree that laboratory experiments are helpful in learning cousre material.
The **lectures** in PHYS*1300 are helpful in learning and understanding the course material.	1.65	-0.58 ***	Students agree strongly that lectures are useful in learning course material, and this result is highly significantly different from their agreement on either homework or labs.

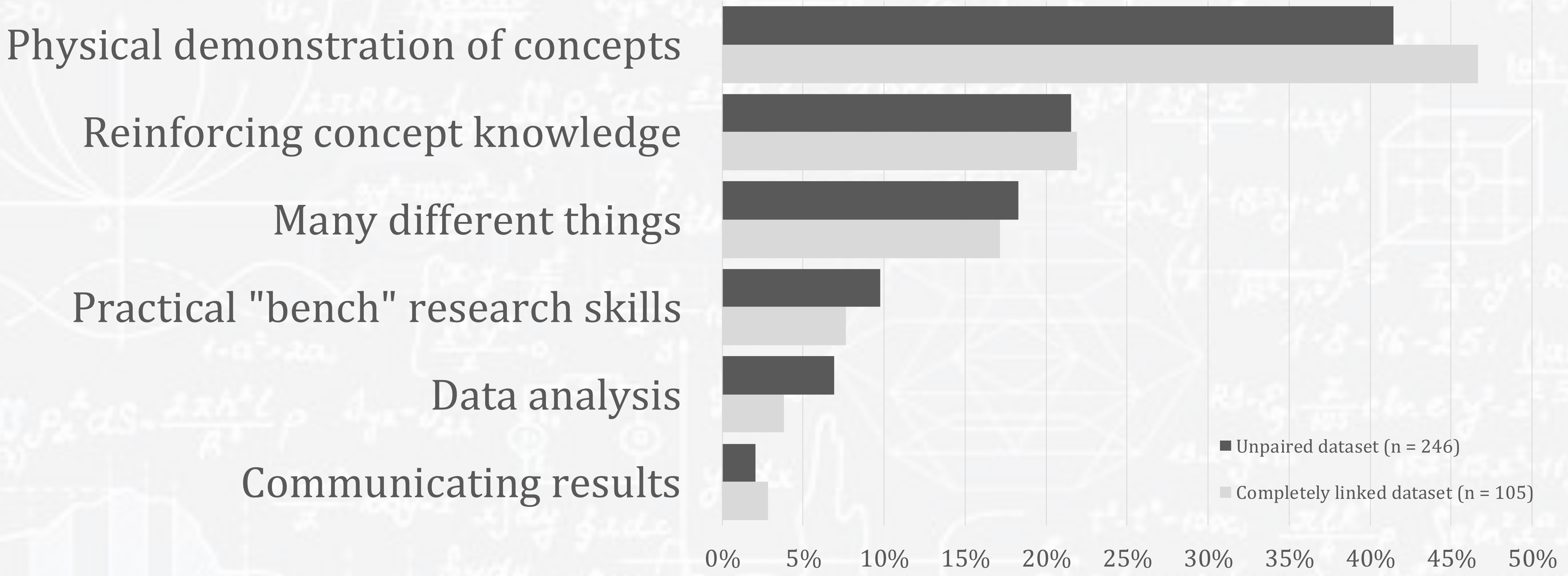
‡ $p > 0.05$ * $p \leq 0.05$ ** $p \leq 0.01$ *** $p \leq 0.001$

$n = 673$

[2] Possible responses 1 (Strongly Agree) 2 (Agree) 3 (Neither Agree Nor Disagree) 4 (Disagree) 5 (Strongly Disagree)

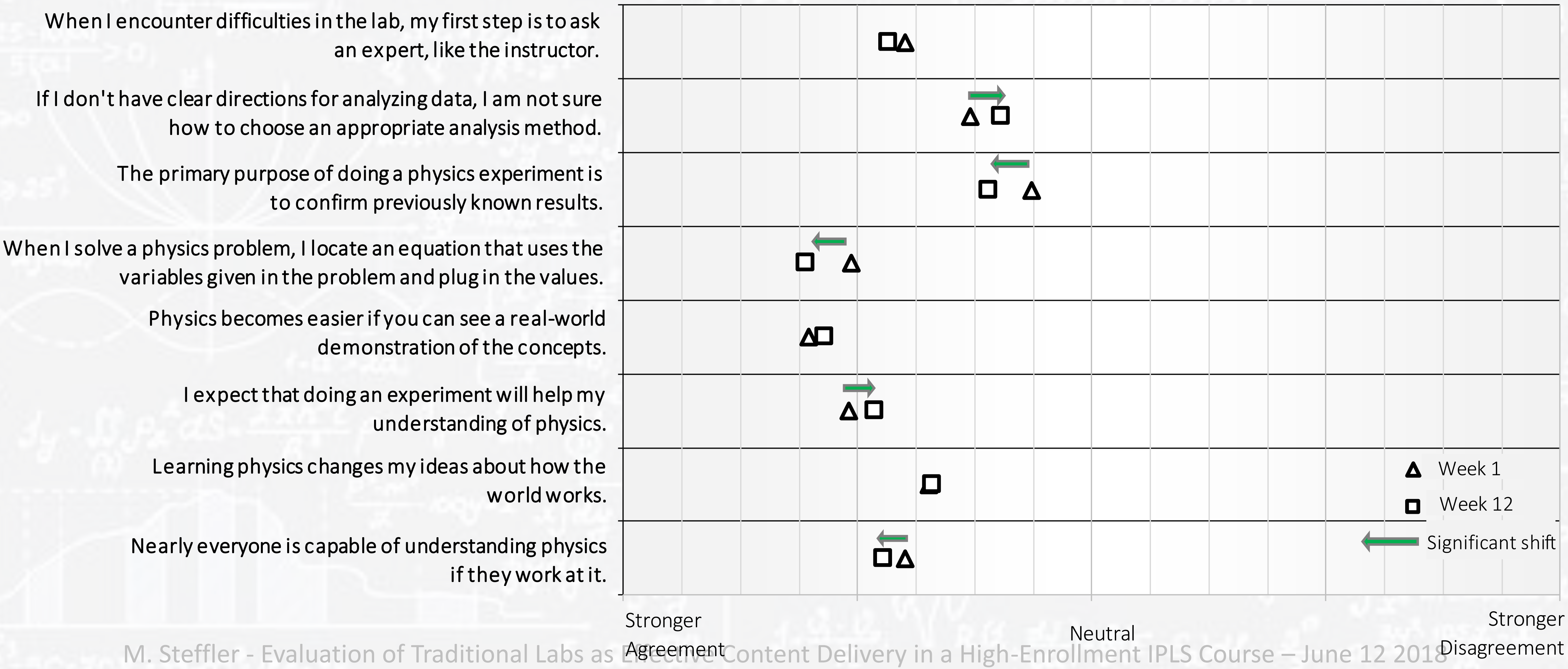
[3] Significance of difference evaluated by both t-test and Wilcoxon signed-rank test, due to questions about normality.

Students think that labs have many roles, and they agree most strongly with the idea that labs should be a physical demonstration of theoretical ideas.



Fraction of students from complete survey selecting response as the primary (most important) role of laboratory exercises in introductory physics courses.

Some mild, unsurprising opinion shifts:



- Wieman and Holmes (2015) and Holmes et al (2017) studies verified in a large enrollment ILPS setting.
- Labs do not appear to reinforce content and students do not appear to expect or need them to, at least primarily.
- Students believe that labs can have many roles. They believe most strongly that they should be a real world demonstration of theoretical concepts.
- After that, they are equally comfortable with labs as content reinforcement, teaching practical bench skills, and teaching data analysis.

Thank you!

Thanks to Prof. O'Meara, the TA's, and students of PHYS*1300 last fall.

1. Wieman, C. & Holmes, N. G. Measuring the impact of an instructional laboratory on the learning of introductory physics. *Am. J. Phys.* **83,** 972–978 (2015)
2. Holmes, N. G., Olsen, J., Thomas, J. L. & Wieman, C. E. Value added or misattributed? A multi-institution study on the educational benefit of labs for reinforcing physics content. *Phys. Rev. Phys. Educ. Res.* **13,** 1–12 (2017).