



WISCONSIN
UNIVERSITY OF WISCONSIN-MADISON

Expanding a Model for Design-based Labs Supported by Whiteboards

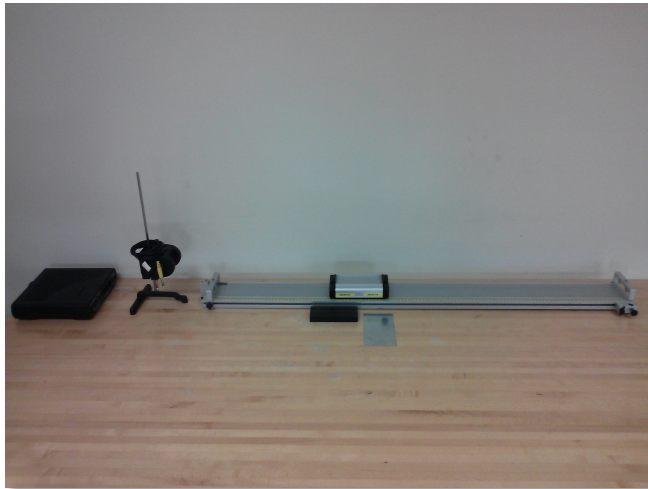
BENJAMIN SPIKE

JULY 24, 2019

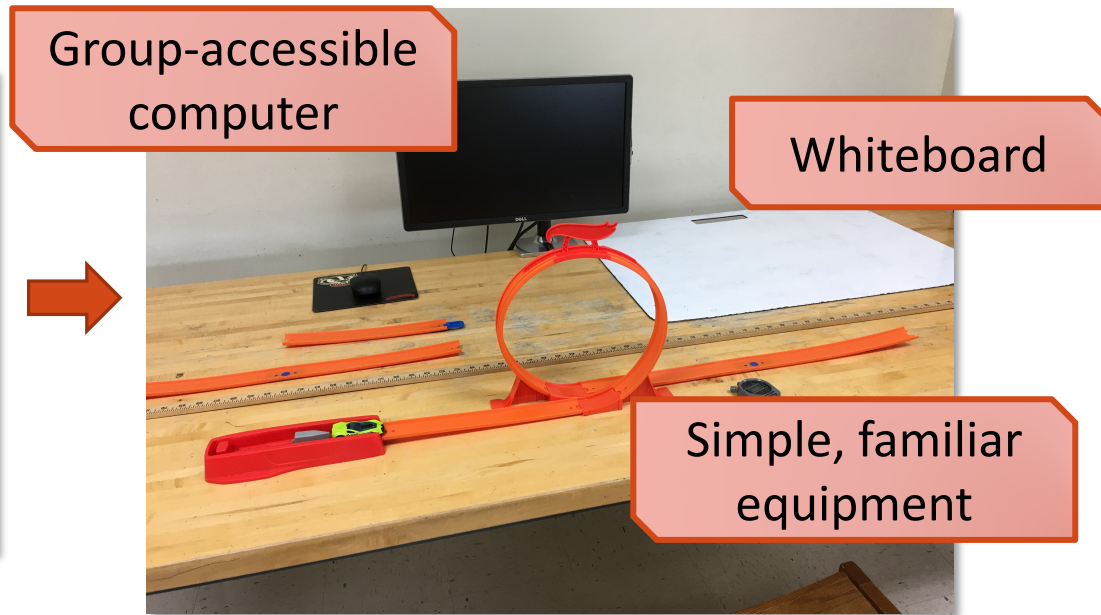
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Spring 2018

- Introduced design-based lab model to Physics 1 (alg.-based)
 - ~500 students/semester, 2-hr labs, 10 labs/semester



Traditional



Group-accessible
computer

Whiteboard

Simple, familiar
equipment

Design-based



Guiding Principles for New Labs

➤ Open-Ended Design

- “Capstone” of each lab is a **design challenge** with multiple possible solutions

➤ Communication

- **Whiteboards** facilitate collaboration & communication
- Mid-lab “**symposium**” provides forum to share ideas

➤ Conceptual Scaffolding

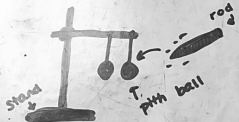
- First half of lab **builds up** & **reinforces** principles that will be used in design challenge



Sample Whiteboard

Diagram of Setup

SET-UP



28.962-M

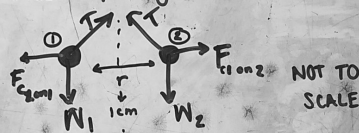
PROCEDURE

- Bring charged rod in between the two pith balls
- Calculate the amount of e^- transferred to one ball by:
 - Find MW and weight of ball

Description of Approach

CALCULATION

Free Body Diagram



NOT TO SCALE

$$W = q \cdot m = 9.8 \cdot 0.0029$$

$$F_{Ty} = W = 0.0029$$

$$F_{Tx} \Rightarrow \tan(5^\circ) = \frac{F_{Tx}}{0.0029}$$

$$F_{Tx} = 2.616 \cdot 10^{-4}$$

$$F_{Tx} = F_c \text{ so } F_c = 2.616 \cdot 10^{-4} \text{ N} = \frac{k \cdot q^2}{r^2} = \frac{9 \cdot 10^9 \cdot q^2}{(0.01)^2}$$

$$\sqrt{\frac{F_c \cdot r^2}{k}} = q = 8.5 \cdot 10^{-10} \text{ C}$$

$$\frac{q}{e} = \frac{8.5 \cdot 10^{-10} \text{ C}}{-1.6 \cdot 10^{-19} \text{ C}} = 5.3$$

ASSUMPTIONS

- The weight of the balls are the same
- The balls have the same charge

Uncertainty & Assumptions

UNCERTAINTY

- Measurement uncertainty of ruler and angle $\pm 0.01^\circ$

CONCLUSION

There were $5.323 \cdot 10^4$ electrons transferred to each ball. 😊

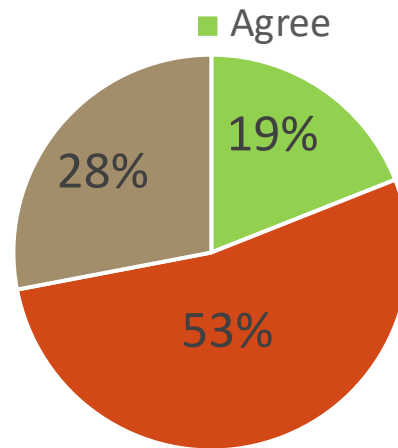
Results & Conclusions

Mathematical Procedure

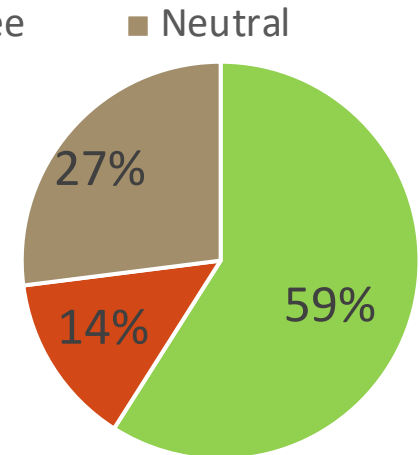


Encouraging Sp18 Results

“I felt like I had to think creatively in order to be successful at the labs.”

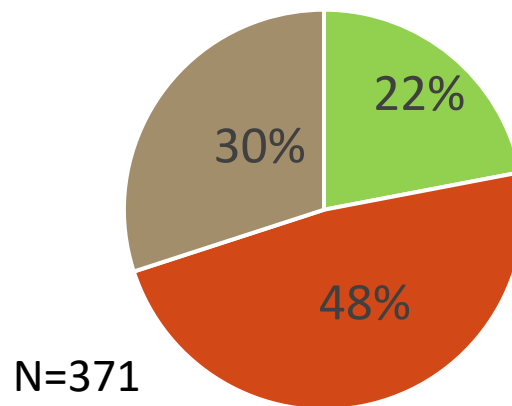


Traditional Physics 2

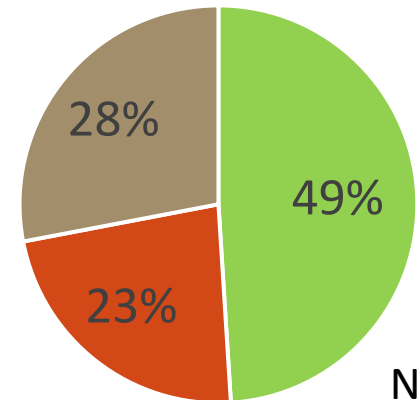


Design-based Physics 1

“Overall, I found the labs interesting.”



N=371



N=311

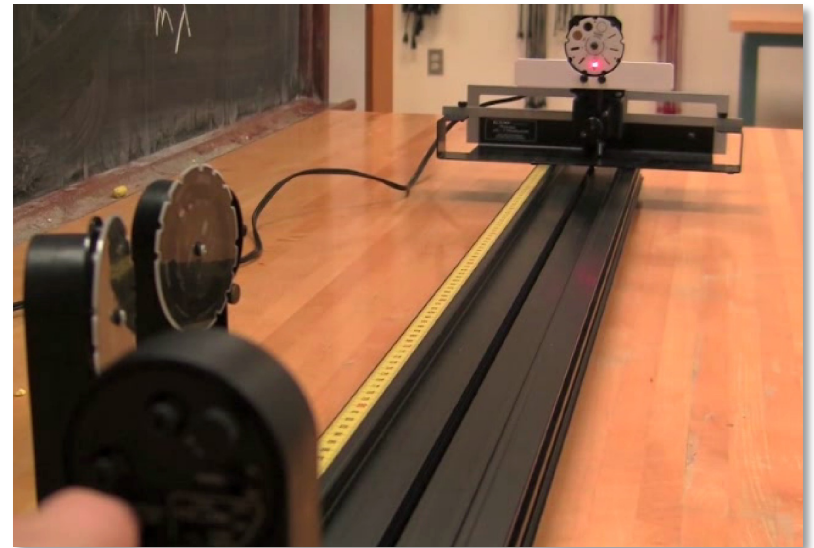


Fall 2018 – Spring 2019

- Model expanded to Physics 2
 - 10 new design-based labs supported by whiteboards



“Build a telescope using the lenses available to you.”



“Measure the width of a hair using the diffraction pattern from a laser.”



Post-semester Survey

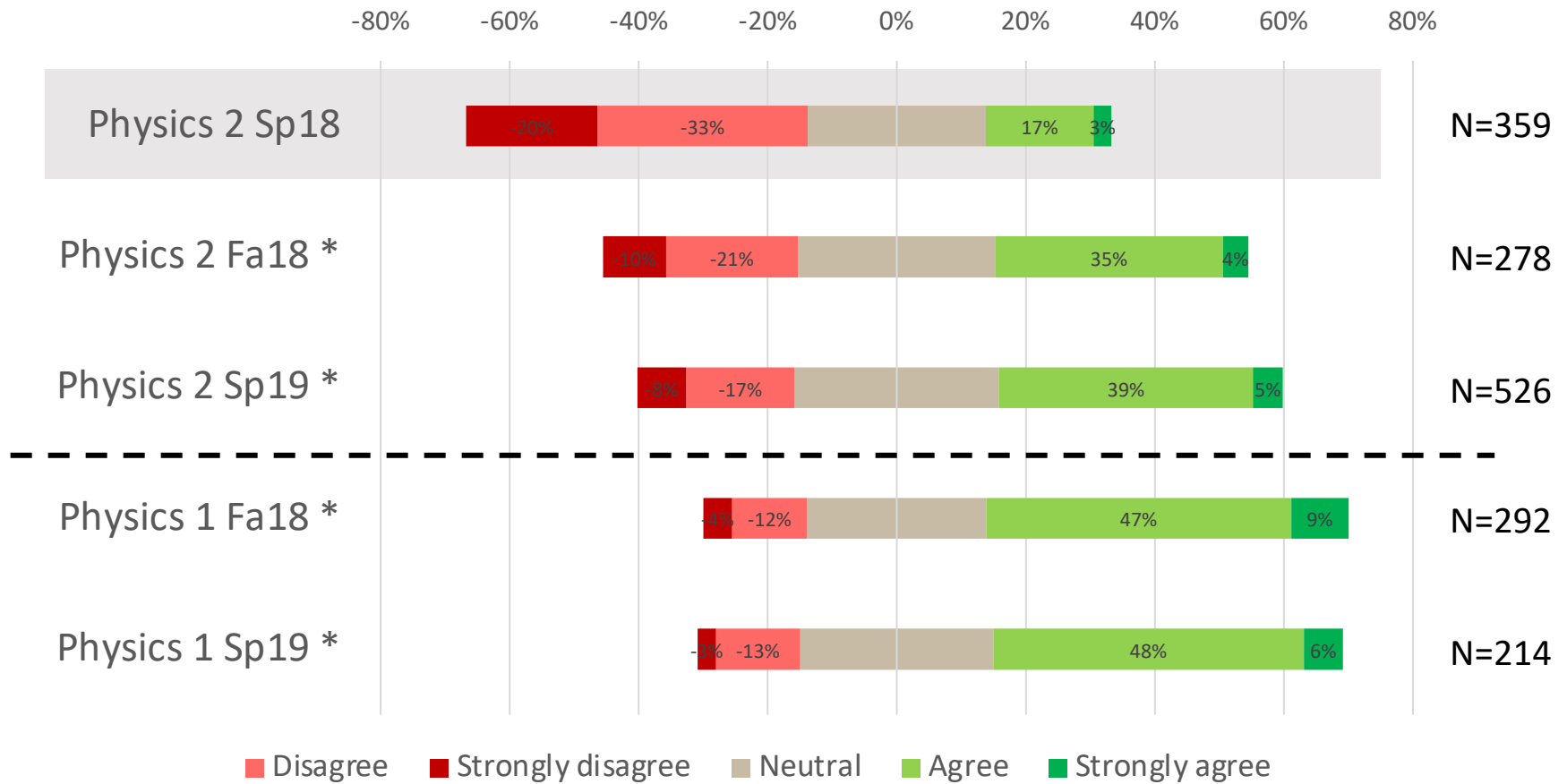
- 12 questions, 5-point Likert scale
 - Strongly Disagree – Disagree – Neutral – Agree – Strongly Agree
- Administered with post-semester conceptual inventories during lab

Spring 2018	Fall 2018	Spring 2019
Physics 1 (New)	Physics 1 (New)	Physics 1 (New)
Physics 2 (Old)	Physics 2 (New)	Physics 2 (New)



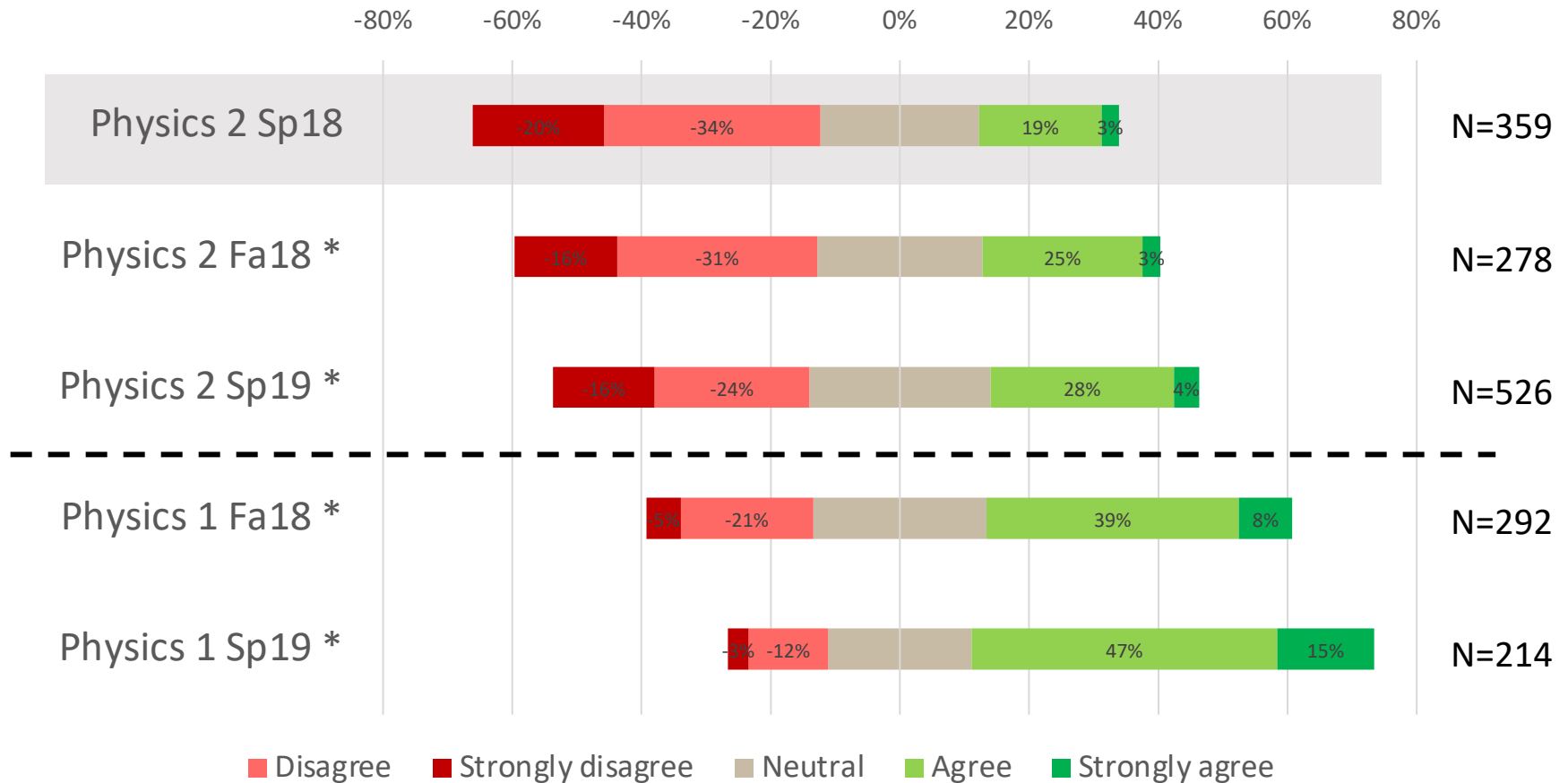
Results: Creativity

“I felt like I had to think creatively in order to be successful at the labs.”



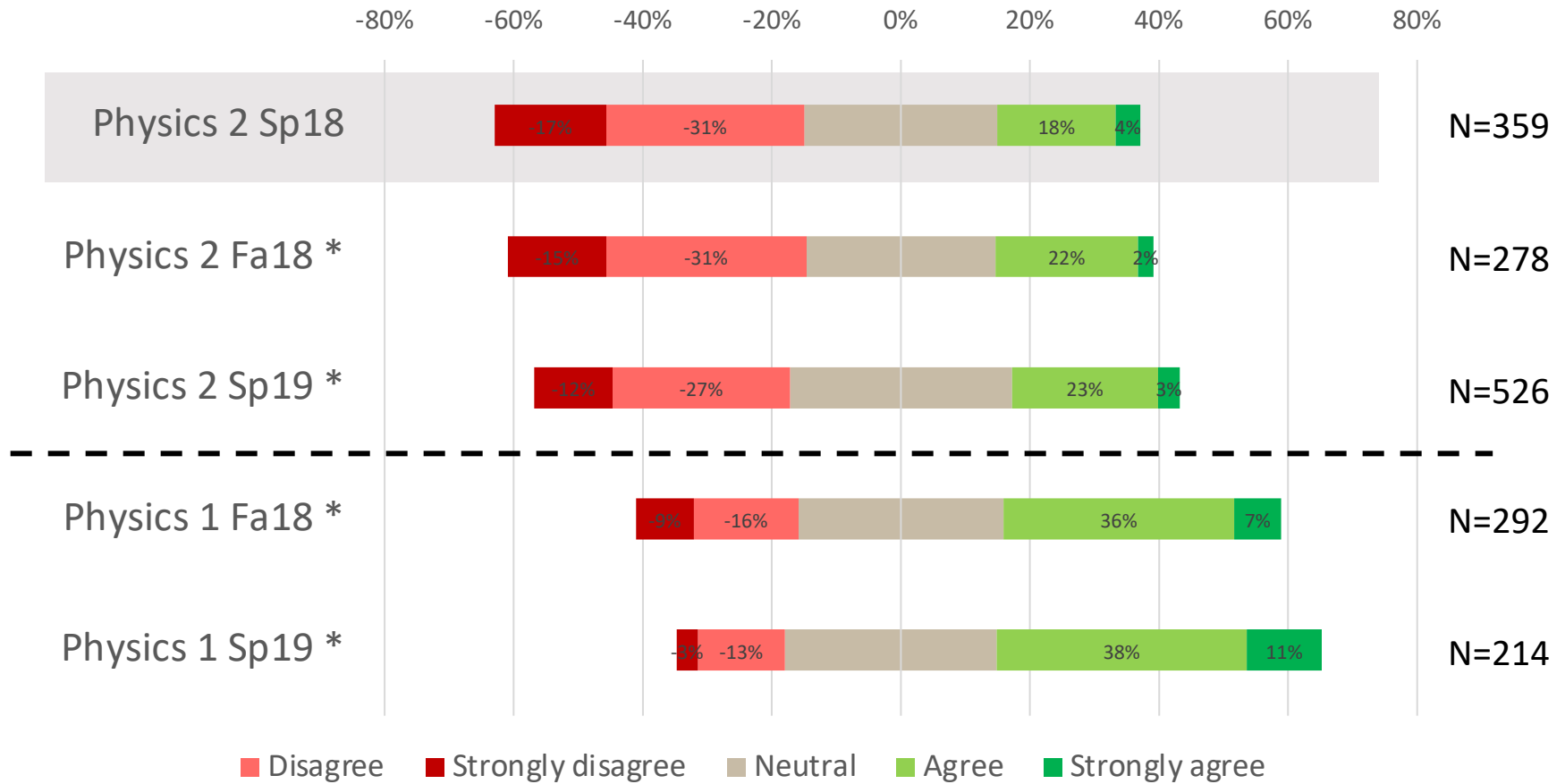
Results: Concept development

“The labs improved my understanding of physics concepts.”



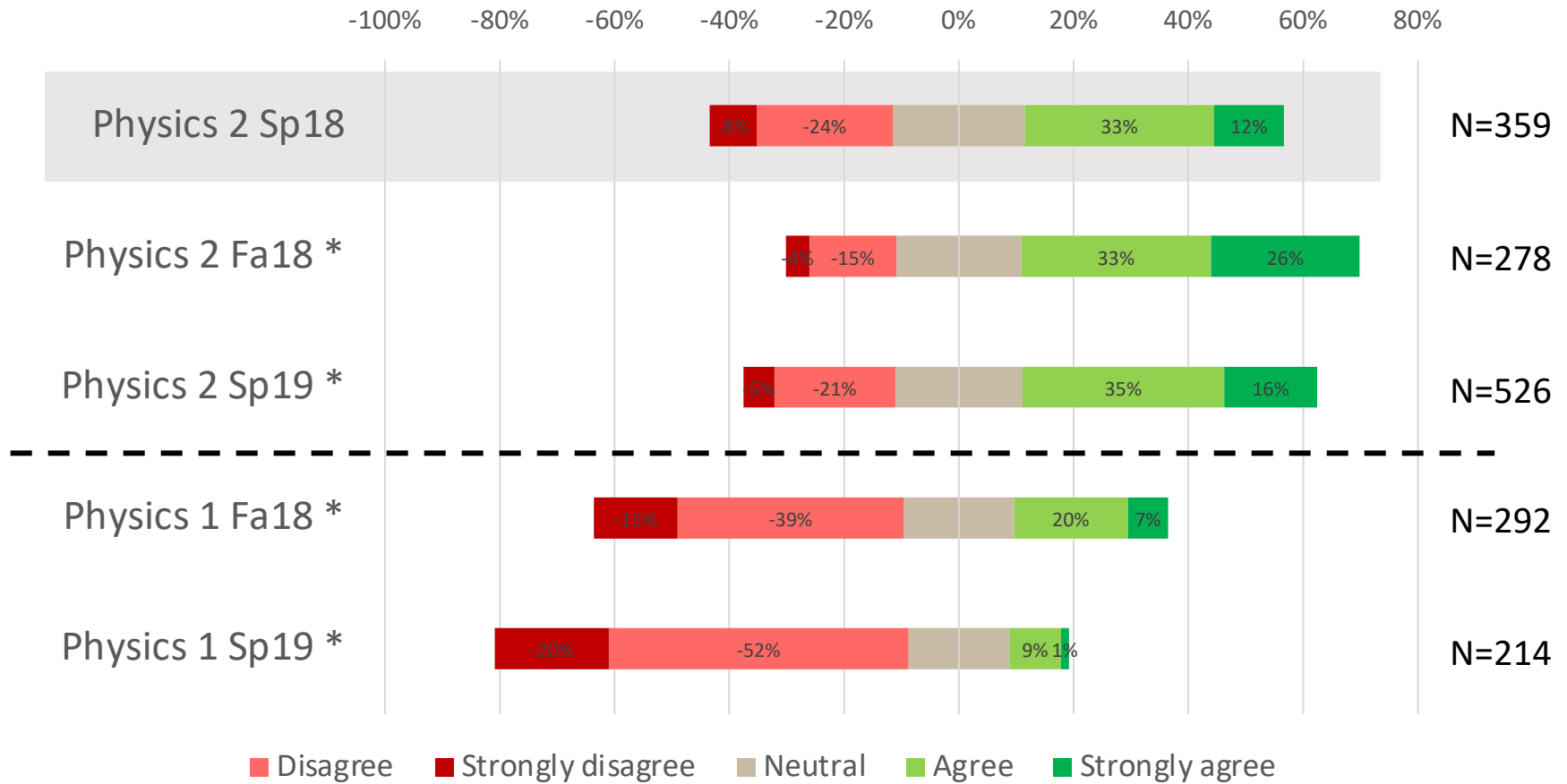
Results: Interest

“Overall, I found the labs interesting.”



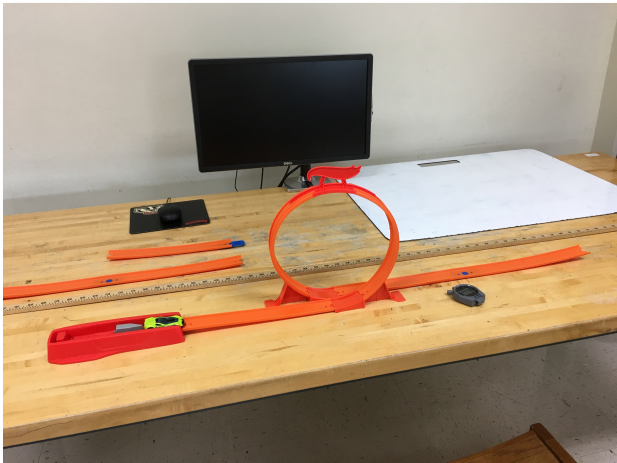
Results: Equipment

“I often had difficulty working with the laboratory equipment.”



Our takeaways

- Students see the design-based Physics 2 labs as requiring more creativity, but do not find them more interesting
- New lab write-ups aren't enough
- Traditional Phys 2 equipment lacks “pick-up-and-playability”



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Summary

- There is substantial room for improvement in our design-based Physics 2 lab suite
- Reliance on traditional laboratory equipment in Physics 2 is possible factor

➤ Future Directions

- Redesign problematic Physics 2 labs from the ground up
- Test out approachable, adaptable tools (e.g. iOLab)
- Conduct classroom observations & interviews to better understand student experience in new lab model



Contributors

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