# Characterizing “Physics Affinity” in Introductory Physics for Life Sciences at Three Institutions

Nikhil Tignor ’24
Swarthmore College

NSF 2142074

# Swarthmore IPLS Curriculum

## IPLS Mechanics

Kinematics and Dynamics: ***random vs. coherent motion, biomechanical stability***

Energy: ***chemical energy***

Fluids: ***cardiology and flight***

Thermo: ***heat conduction and free energy***

## IPLS E&M

Electricity/circuits: ***cell membrane, nerve signaling***

Magnetism and induction: ***magnetic sensing, NMR***

Optics: ***animal vision and microscopy***

Waves: ***echolocation***

# Swarthmore IPLS Curriculum

## IPLS Mechanics

Kinematics and Dynamics: ***random vs. coherent motion***, ***biomechanical stability***

Energy: ***chemical energy***

Fluids: ***cardiology and flight***

Thermo: ***heat conduction*** *and* ***free energy***

## IPLS E&M

Electricity/circuits: ***cell membrane, nerve signaling***

Magnetism and induction: ***magnetic sensing, NMR***

Optics: ***animal vision and microscopy***

Waves: ***echolocation***

Animal Physiology

Cell Biology

Neurobiology

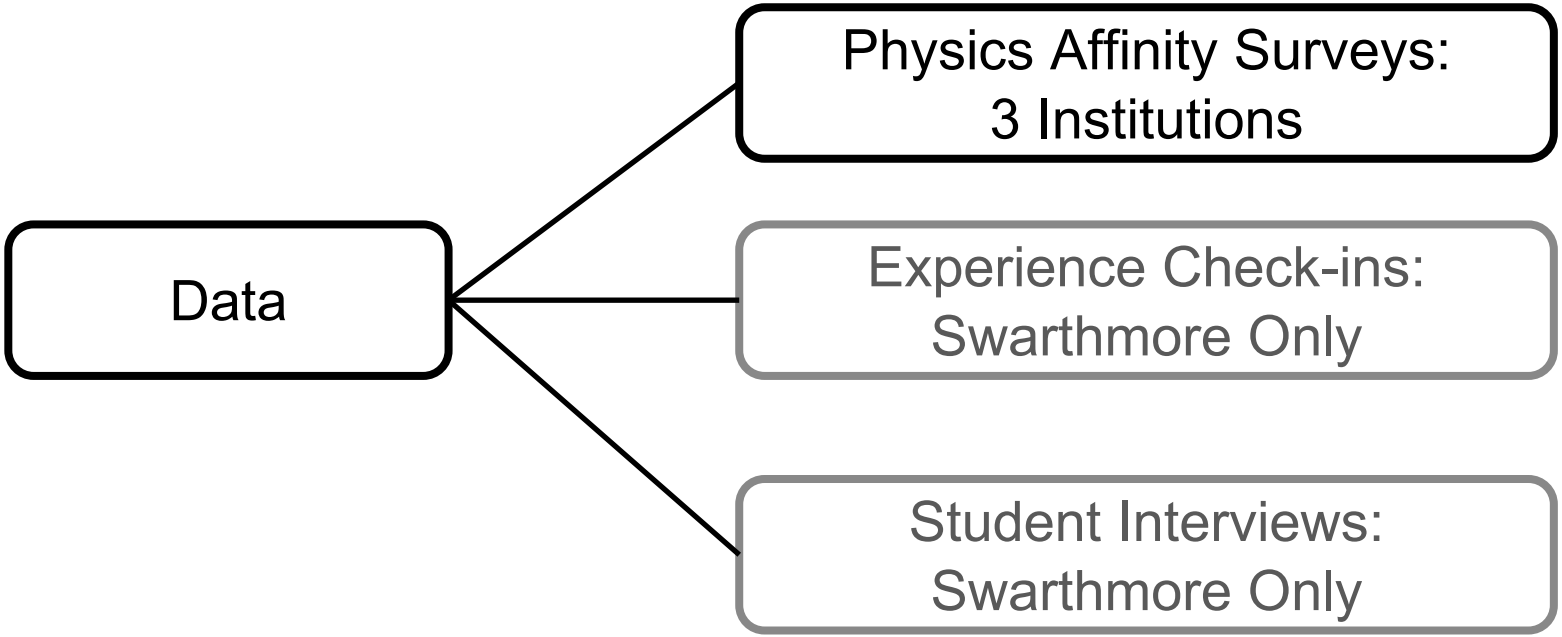
(Bio)chemistry

# Prior Longitudinal Findings at Swarthmore

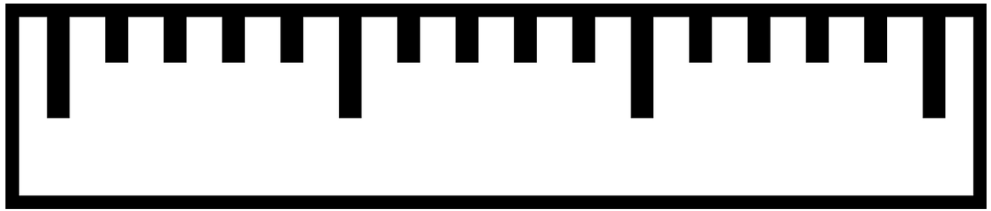
Attitudes and skill gains that were durable over at least a year

Geller & Tipton et al., PR-PER (2022), Geller & Rubien et al., PR-PER (2022), Rak et al., AAPT Talk (2020).

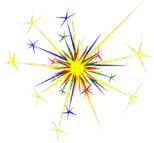
# Data Streams to Investigate Source of IPLS Gains



# “Physics Affinity”



## Example Item



Interest
(8 items)

"When I'm working on something in physics that I think is interesting, I continue working even when it takes a lot of time."

items adapted from *Four-Phase Interest Development in Engineering Survey*, FIDES 2.0

Self-Efficacy
(8 items)

"I do not worry about my ability to solve physics problems."

items adapted *Physics Self-Efficacy Survey*, PSES

Physics Relevance to Bio (4 items)

"Physics is relevant for understanding biological processes."

items adapted from the *MBEX Interdisciplinary Cluster items*

Physics Affinity

# Project Question:

How do students' Physics Affinity scores develop in response to different instructional environments?

# Characterizing Instructional Environments

## "Yellow U"

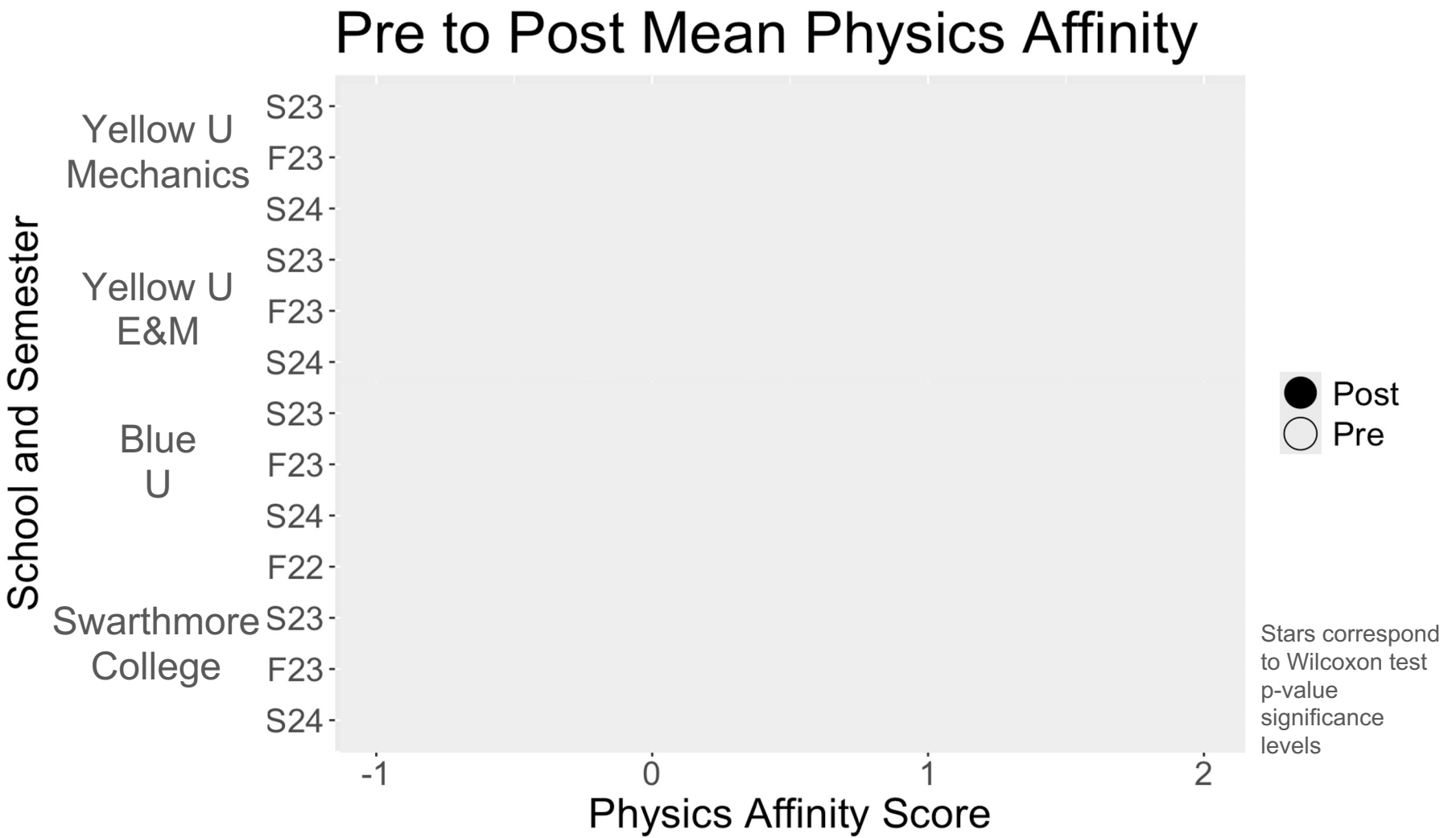
- Large public research university
- Very experienced instructor
- Relatively little LS connection
- Carefully crafted learning progression

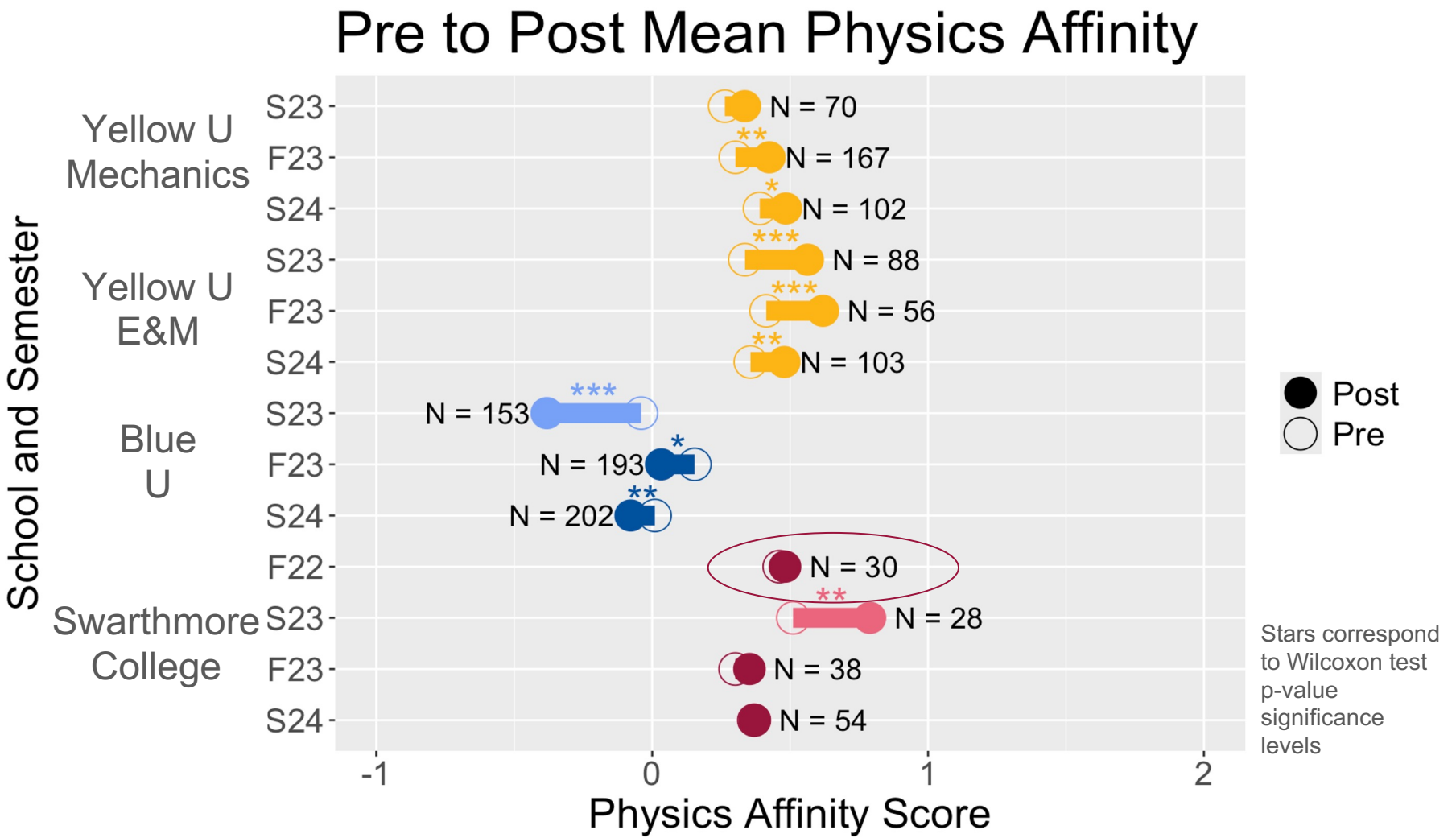
## "Blue U"

- Large R1 university
- Two instructors, both new to institution
- Instr. 1: almost no LS integration
- Instr. 2: many more LS connections

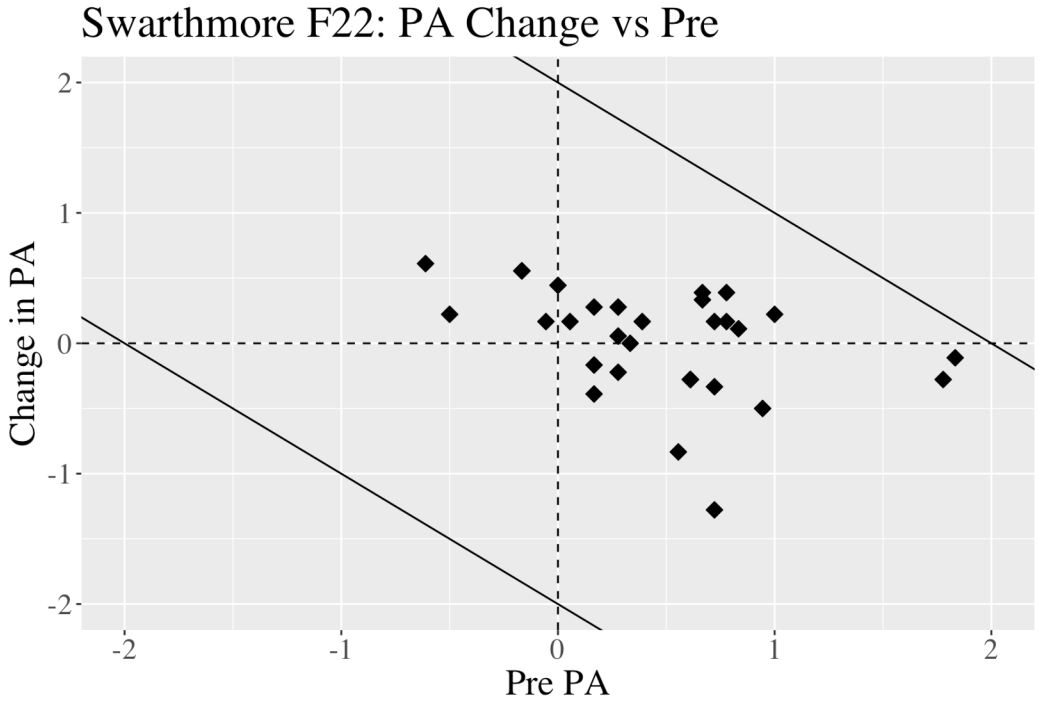
## Swarthmore College

- Small liberal arts college
- Instr. 1: prioritized comfortable class environment, modest LS connections
- Instr. 2: prioritized LS connections, gave more challenging assessments


Pre to Post Mean Physics Affinity
School and Semester
Yellow U Mechanics
Yellow U E&M
Blue U
Swarthmore College
S23
F23
S24
S23
F23
S24
S23
F23
S24
F22
S23
F23
S24
-1
0
1
2
Physics Affinity Score
Post
Pre
Stars correspond to Wilcoxon test p-value significance levels


Pre to Post Mean Physics Affinity
School and Semester
Yellow U Mechanics
Yellow U E&M
Blue U
Swarthmore College
S23
F23
S24
S23
F23
S24
S23
F23
S24
F22
S23
F23
S24
N = 70
**
N = 167
*
N = 102
***
N = 88
***
N = 56
**
N = 103
***
N = 153
*
N = 193
**
N = 202
N = 30
**
N = 28
N = 38
N = 54
-1
0
1
2
Physics Affinity Score
Post
Pre
Stars correspond to Wilcoxon test p-value significance levels

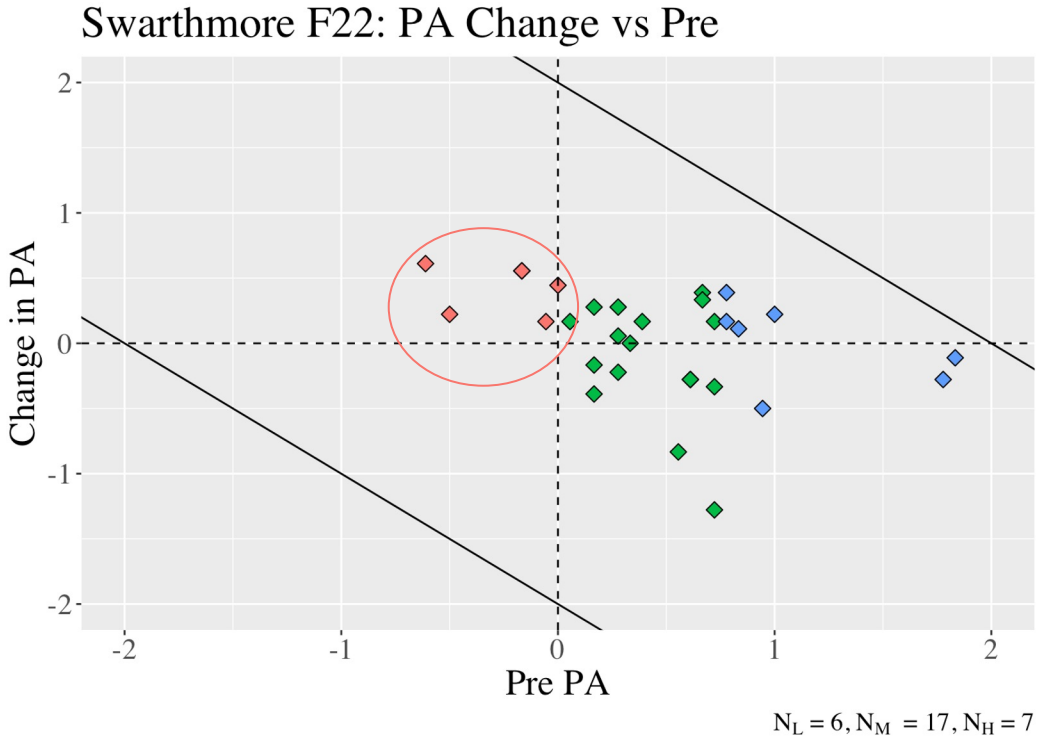
# Change in Affinity




$\mu_{\Delta PA}$ = 0.02, ns

N = 30

# Change in Affinity: Initial Affinity Levels




Low Pre-PA

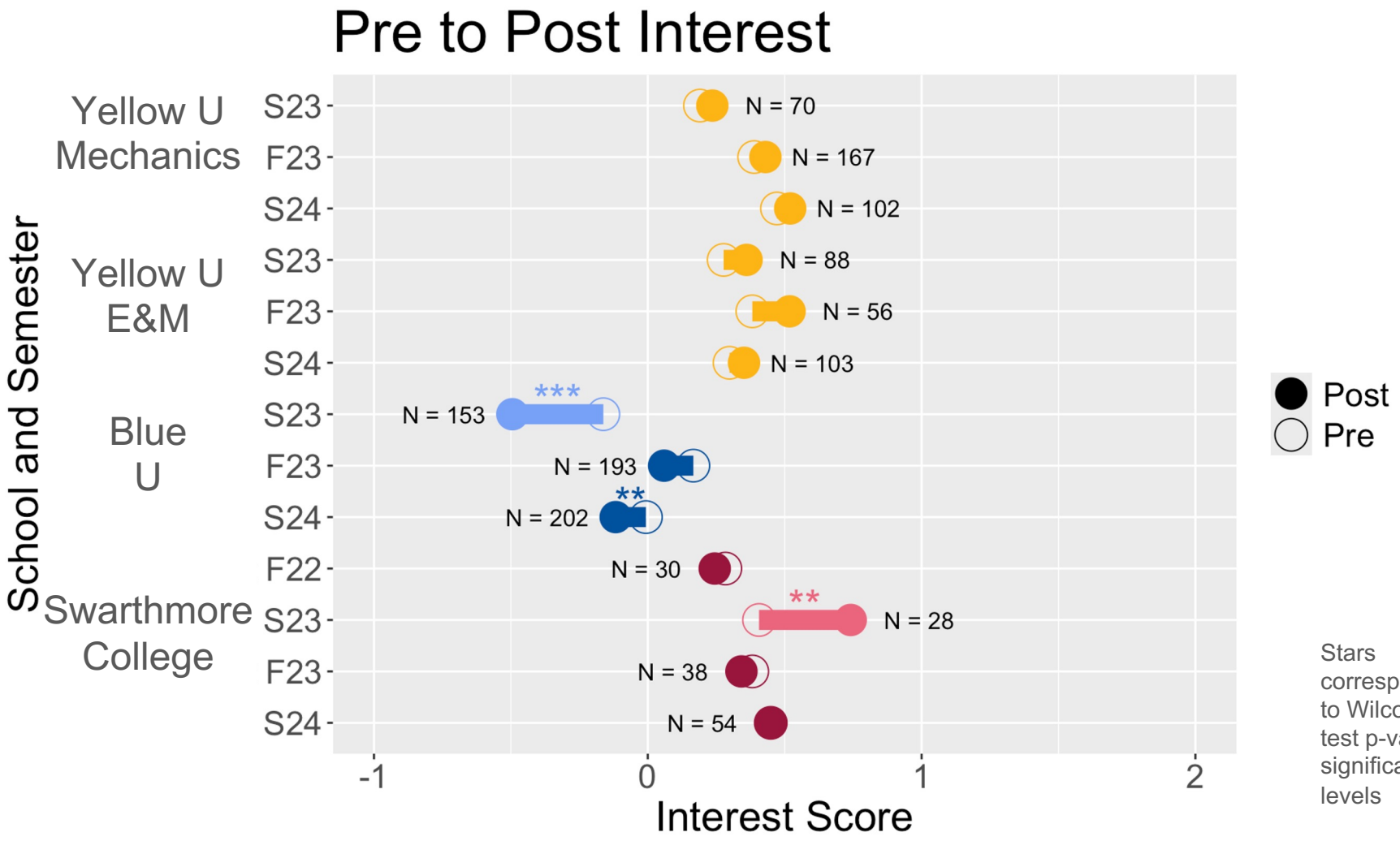
$\mu_{\Delta PA} = 0.43$ *

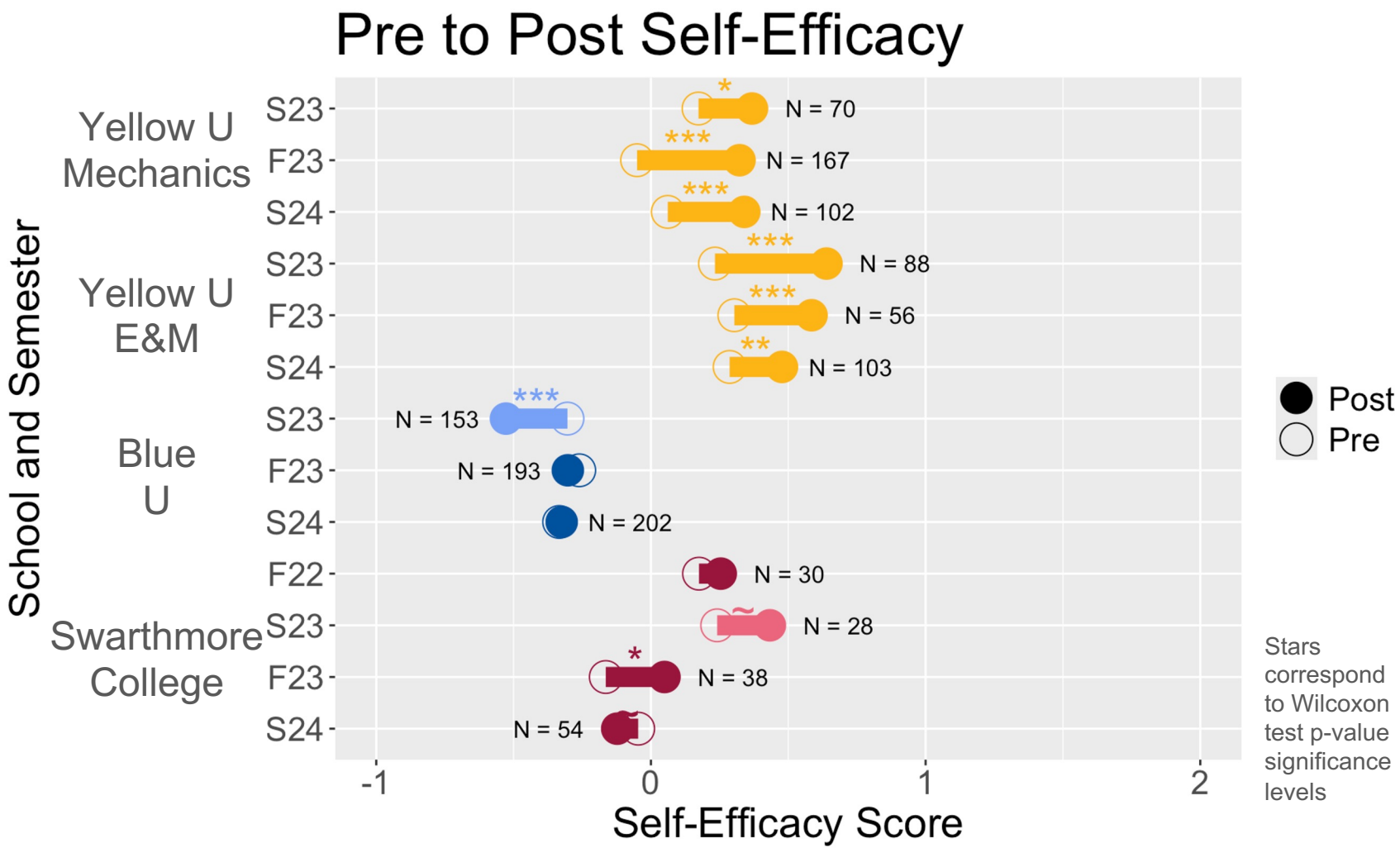
Medium Pre-PA

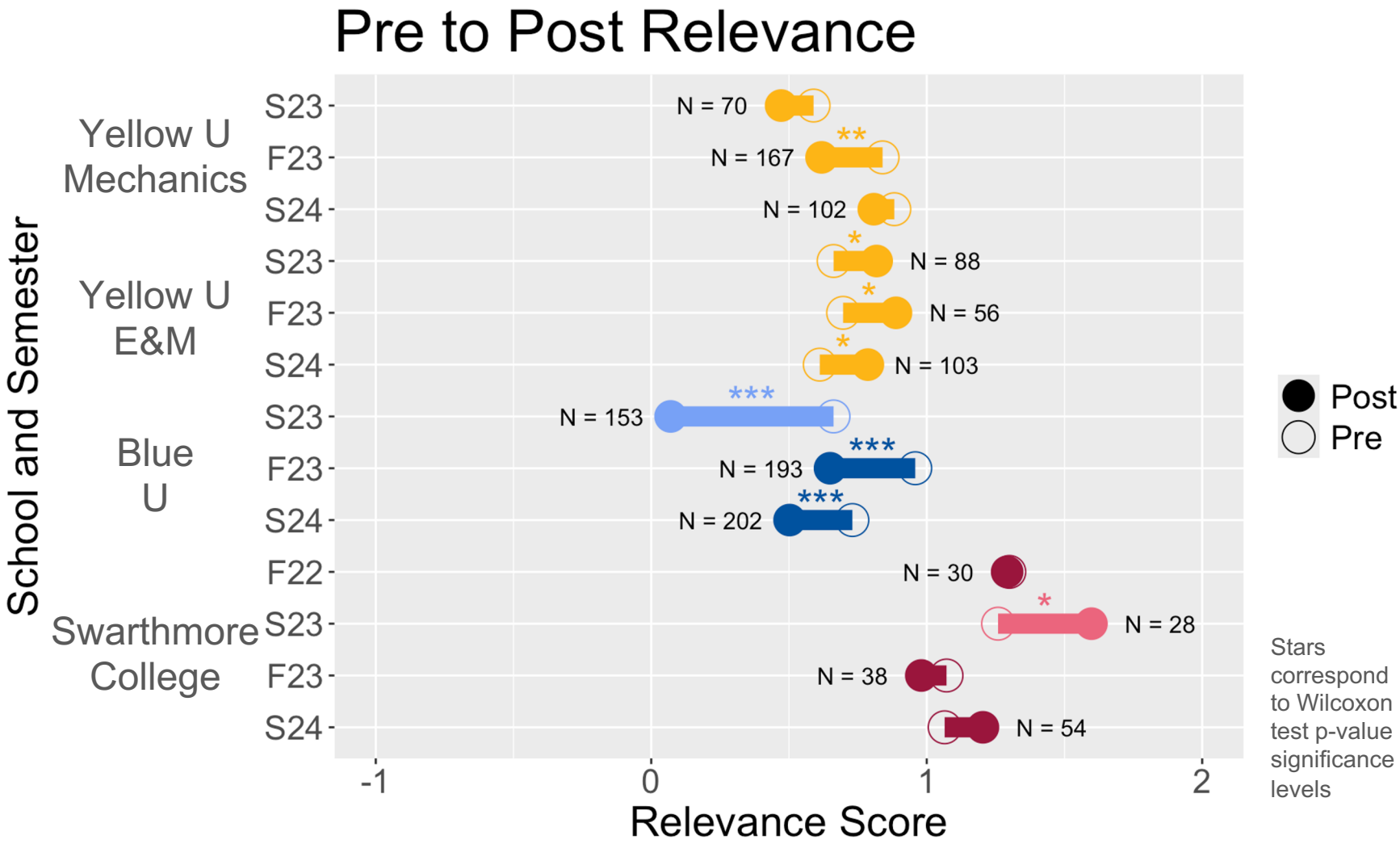
$\mu_{\Delta PA} = -0.11$ ns

High Pre-PA

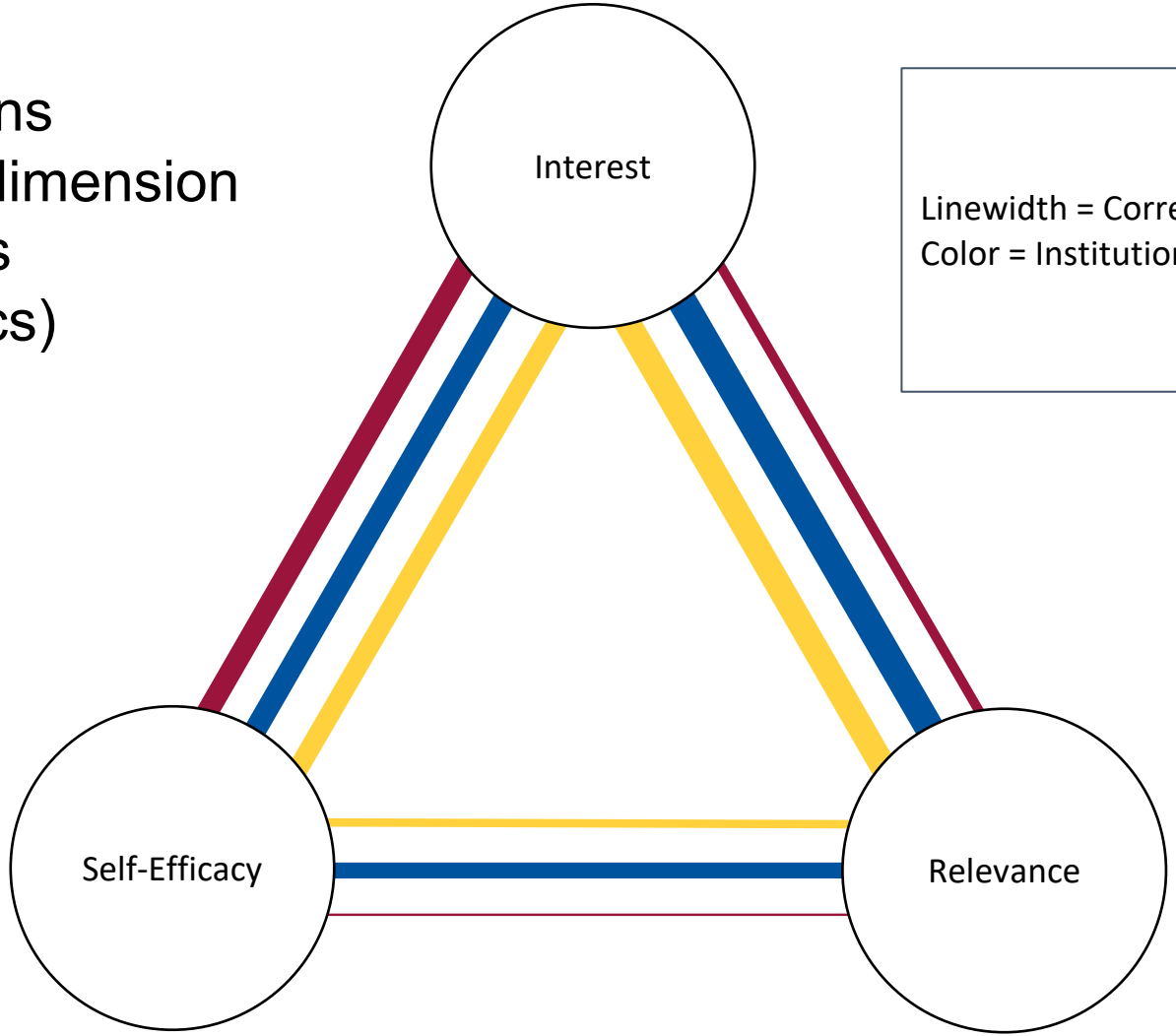
$\mu_{\Delta PA} = 0$ ns


Pre to Post Interest
School and Semester
Yellow U Mechanics
Yellow U E&M
Blue U
Swarthmore College
S23
F23
S24
S23
F23
S24
S23
F23
S24
F22
S23
F23
S24
N = 70
N = 167
N = 102
N = 88
N = 56
N = 103
N = 153
***
N = 193
N = 202
**
N = 30
N = 28
**
N = 38
N = 54
-1
0
1
2
Interest Score
Post
Pre
Stars correspond to Wilcoxon test p-value significance levels


Pre to Post Self-Efficacy
School and Semester
Yellow U Mechanics
Yellow U E&M
Blue U
Swarthmore College
S23
F23
S24
F22
S23
F23
S24
S23
F23
S24
S23
F23
S24
*
N = 70
***
N = 167
***
N = 102
***
N = 88
***
N = 56
**
N = 103
***
N = 153
N = 193
N = 202
N = 30
N = 28
*
N = 38
N = 54
-1
0
1
2
Self-Efficacy Score
Post
Pre
Stars correspond to Wilcoxon test p-value significance levels


Pre to Post Relevance
School and Semester
Yellow U Mechanics
Yellow U E&M
Blue U
Swarthmore College
S23
F23
S24
S23
F23
S24
S23
F23
S24
F22
S23
F23
S24
N = 70
**
N = 167
N = 102
*
N = 88
*
N = 56
*
N = 103
***
N = 153
***
N = 193
***
N = 202
N = 30
*
N = 28
N = 38
N = 54
-1
0
1
2
Relevance Score
Post
Pre
Stars correspond to Wilcoxon test p-value significance levels

# Correlations between dimension pre scores (Mechanics)




Linewidth = Correlation Strength
Color = Institution

# Summary

- “Yellow U” instructor achieved notable gains in self-efficacy without corresponding gains in interest or relevance, in a course with very few LS connections

- “Blue U” students began with significantly lower affinity, which decreased over the course of the semester, but instruction emphasizing LS connections dramatically mitigated those losses.

- At Swarthmore, the overall PA scores increased significantly with instructor 2, while only low initial affinity students showed significant gains with instructor 1
  - Both instructors used the same curriculum, but instructor 2 emphasized life science connections more dramatically via messaging and course structure
  - The next talk will unpack differences in instructor priorities and detailed course choices

# Conclusion

- Characterized LS student gains in three dimensions of physics affinity at multiple institutions
- Established baseline outcome at Blue U before possible intervention
- Established physics affinity outcomes from a variety of instructional environments and curricular choices

# Thank you for listening!

NSF 2142074

**Acknowledgements**

Lundy Zheng ‘26

Catherine H. Crouch

Stephen Hackler

Benjamin D. Geller

Thanks to Drake Roth and Angelina Tjia for development of introductory slides.

Drake Roth ‘25

Angelina Tjia ‘26

Advisory board: Andrew Boudreaux, Eric Brewe, Tim Nokes-Malach, Ann Renninger, Laura Ríos

Collaborators: Lili Cui, Alfredo Sanchez, Dan Young

Swarthmore PER talk slides and posters:

PERC poster: Weds 4:10 PM (PERC Poster Session 1)

## Any Questions?