Exploring the Impact of IPLS on Student Learning in Neurobiology

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NSF 1710875

Why Neurobiology?

- Key element of electricity unit of the second semester IPLS course

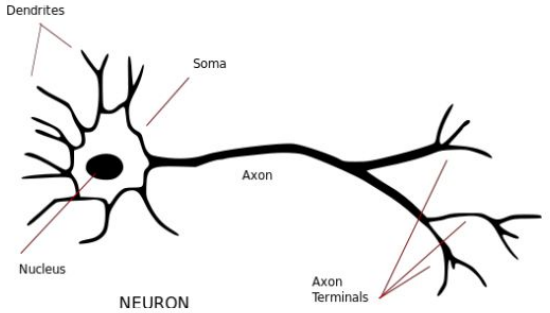


Figure 1. Schematic showing the parts of a neuron. Figure from Wikimedia Commons.

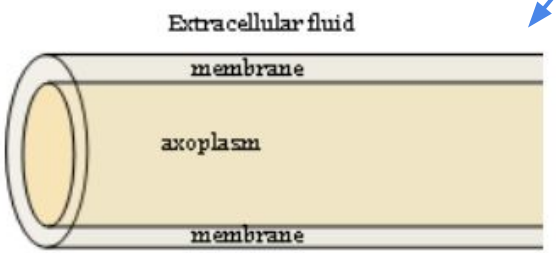
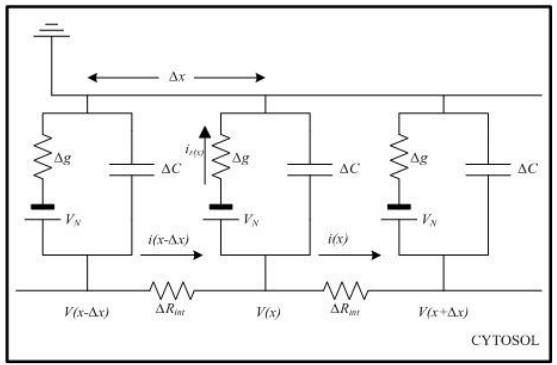


Figure 2. Simplified axon geometry.



(Phillips, Kondev and Theriot 2009, 668)
Diagram 5 - A circuit of the voltage variation of an action potential

Research Questions

In their later life science coursework, do IPLS students, compared to their peers with traditional introductory physics or no physics background:

1. View physics and math as more relevant to and connected with their life science coursework?
    a. Do their attitudes change during Neurobiology?
2. Demonstrate a greater ability to leverage physics competencies in their later life science coursework?

Data sources from Neurobiology

- **Pre-course and Post-course surveys** (attitudes toward relevance of physics and math to biology)
  - Level of agreement to statements regarding interdisciplinarity[1]
    - e.g. "*It is beneficial to me, as a biologist, to also be proficient in physics*"
- **Final Exam** (open-ended)

[1] K. Hall, Ph.D thesis, 2013

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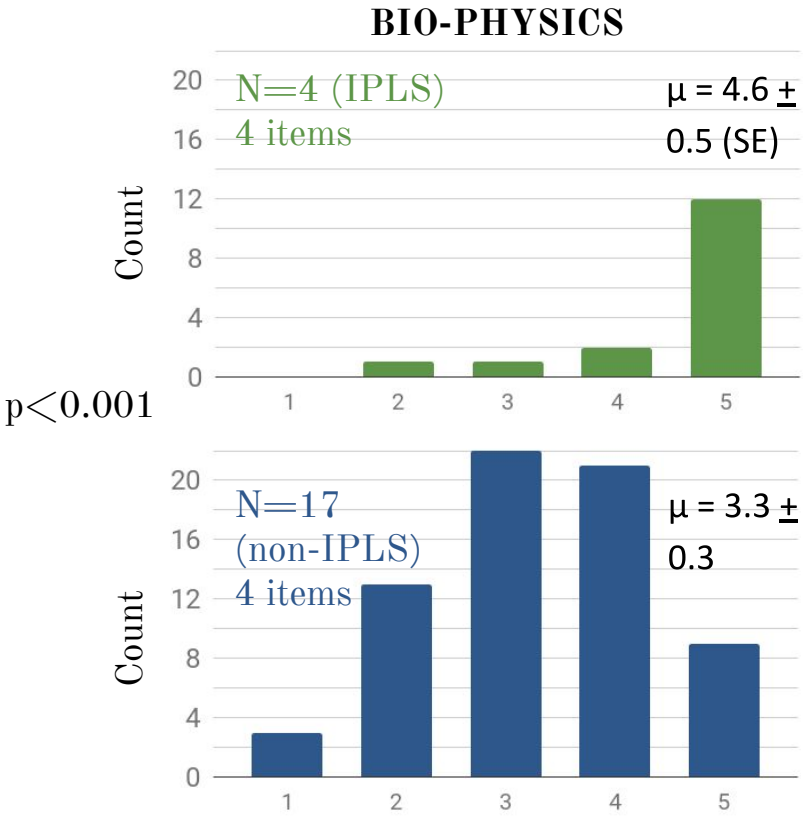
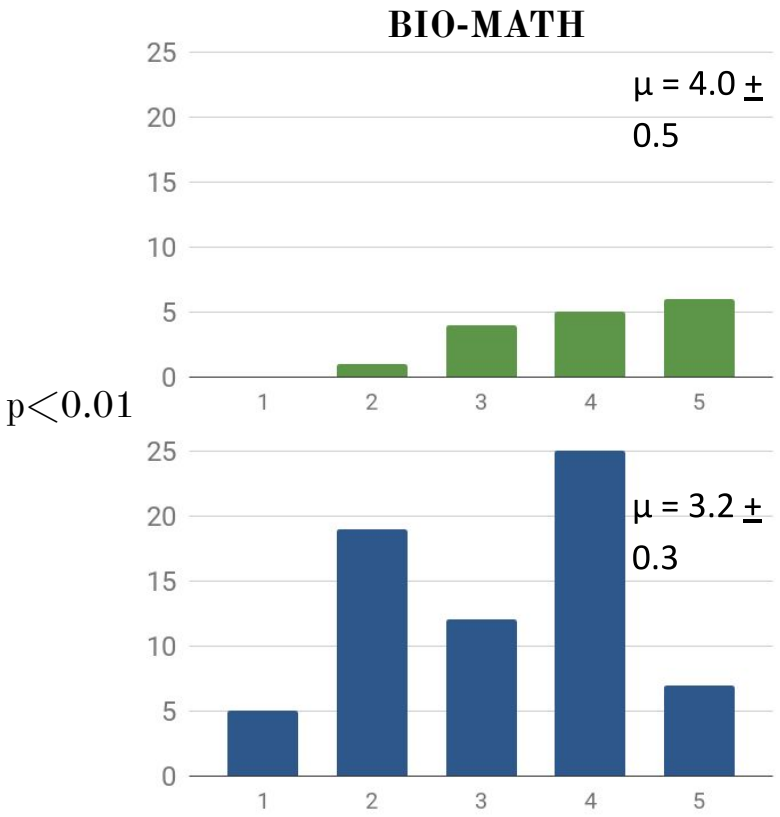
Pre-Neuro Survey: IPLS students express more positive sentiments about the relevance of physics and math





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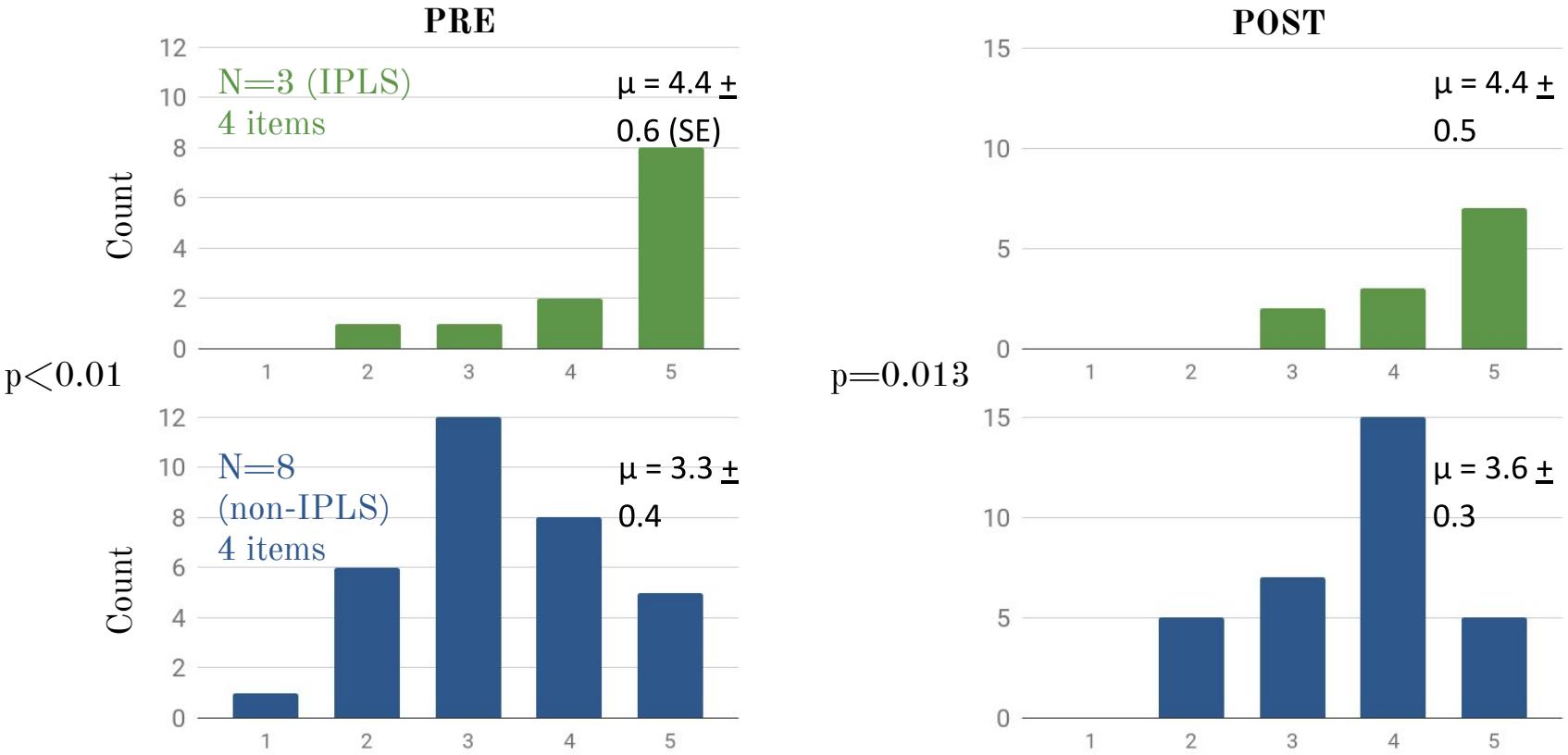
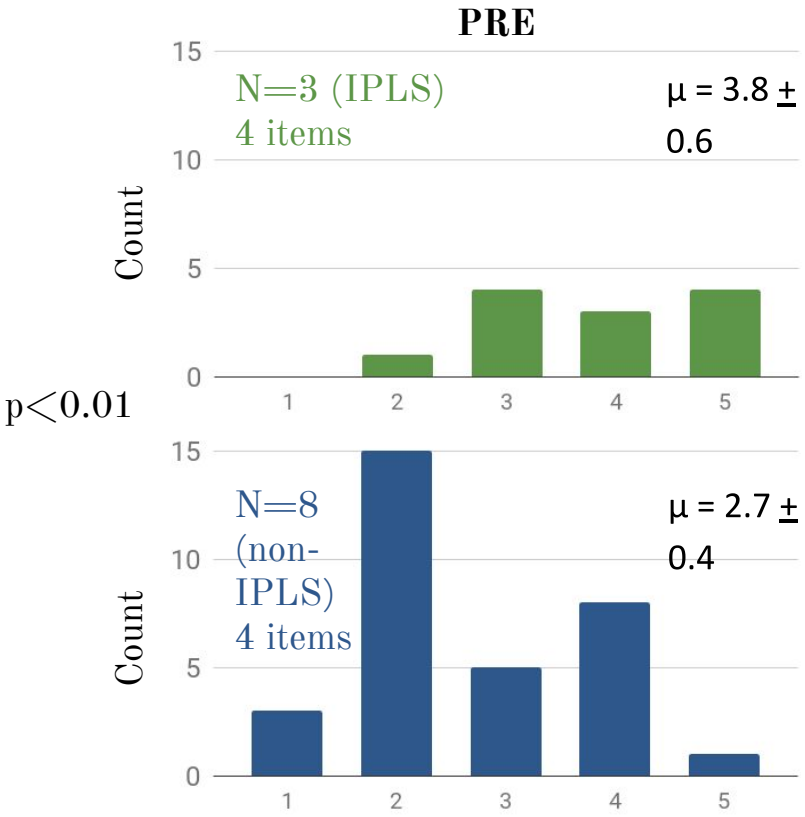
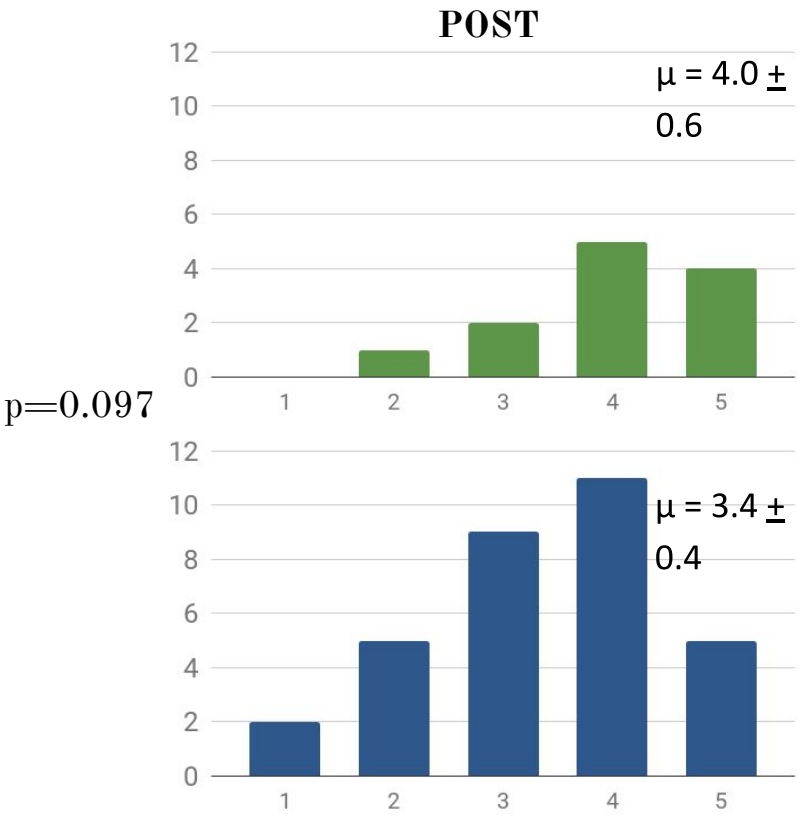
Bio-Physics Connections: Positive sentiments persist in IPLS and increase in non-IPLS



Bio-Math Connections: Same trend





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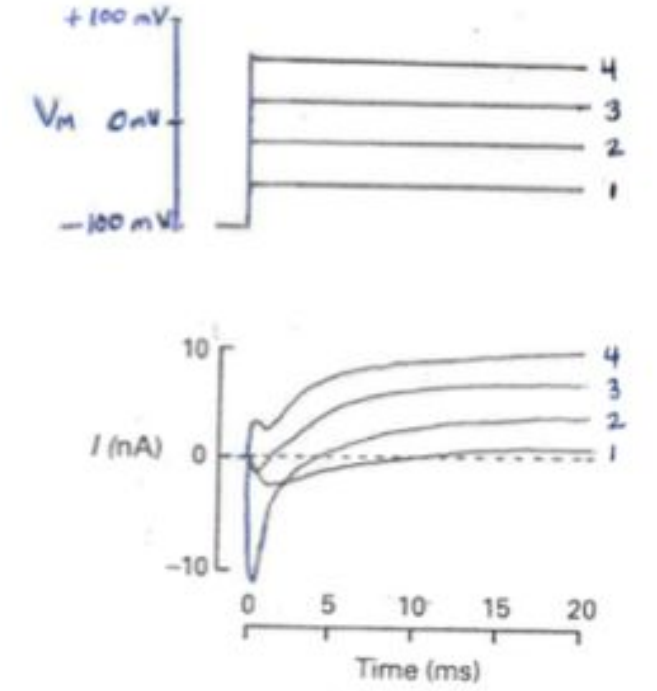
    a. Do their attitudes change during Neurobiology?

2. **Demonstrate a greater ability to leverage physics competencies in their later life science coursework?**

Neurobiology Final

Q1) The data in this figure (right) were obtained from a voltage clamp experiment on a frog axon in normal saline. The membrane potential (V_M) was clamped at -100 mV, then depolarized to different levels as indicated in the upper panel: -60 mV (step 1), -20 mV (step 2), +20 mV (step 3), and +60 mV (step 4). The resulting membrane currents (I, nA) are shown in the lower panel, with responses to the four voltage steps superimposed on the same graph.



A. Explain why the late component of the membrane current response becomes increasingly more positive with increasing depolarization.
B. Explain why the early component of the current response is more negative for step 2 than step 1.
C. Explain why the early component of the current response is less negative for step 3 than step 2.
D. Explain why the early component of the current response switches polarity (from negative to positive) between step 3 than step 4.

Neurobiology Final

Q1) The data in this figure (right) were obtained from a voltage clamp experiment on a frog axon in normal saline. The membrane potential (V_m) was clamped at -100 mV, then depolariz
-60 mV (s
(step 4). T
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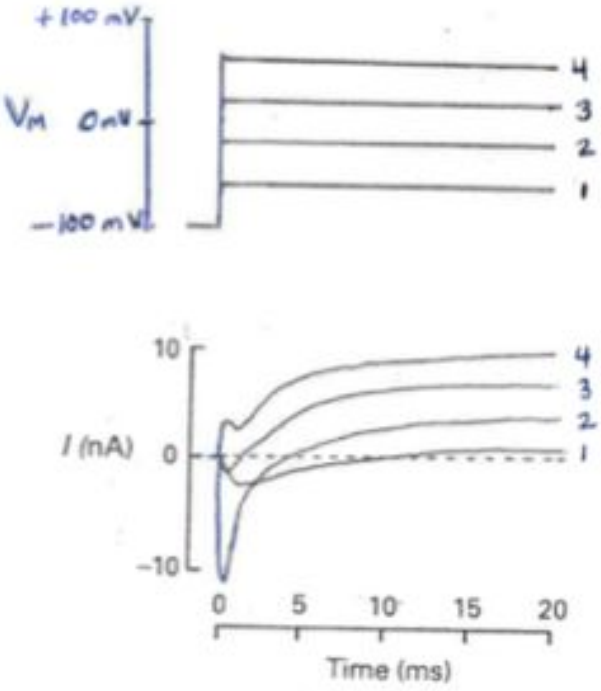
superimp

Students must explain why a change in membrane potential (top graph) leads to different outcomes for current (bottom graph)



negative for step 3 than step 2.

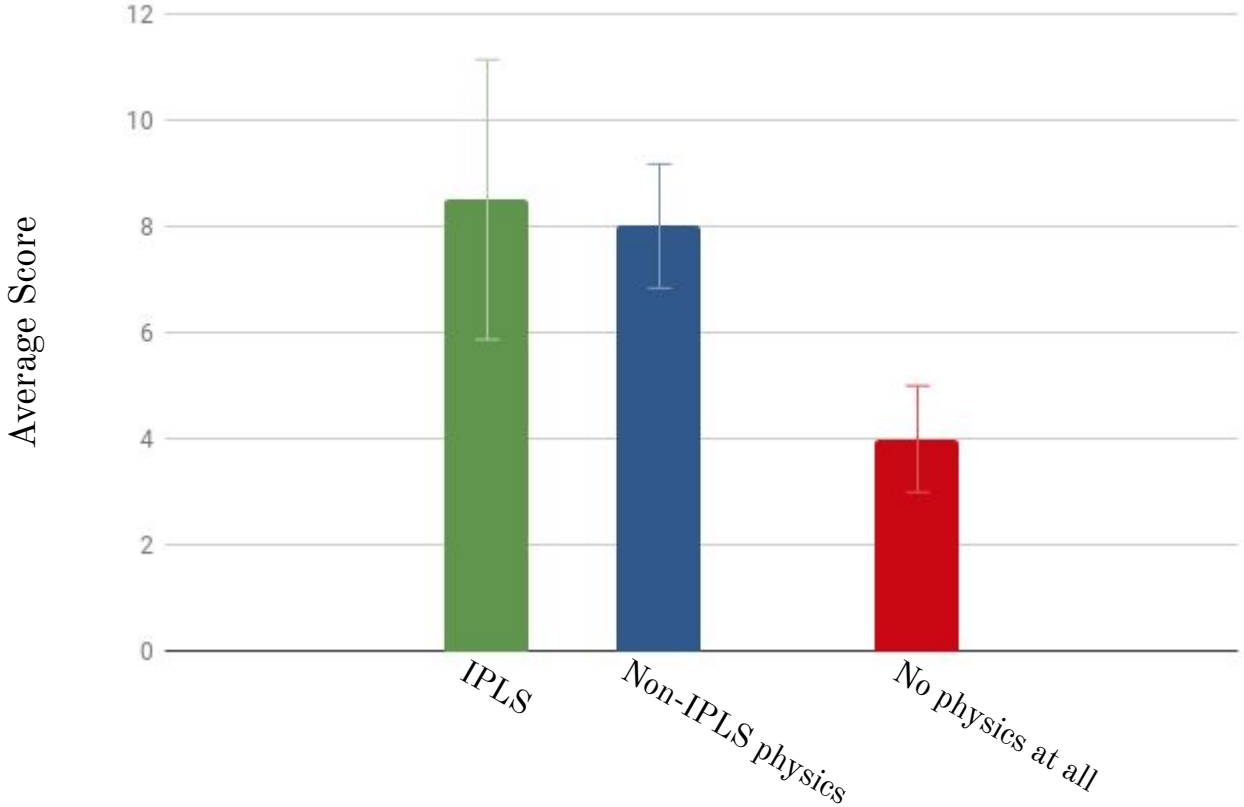
D. Explain why the early component of the current response switches polarity (from negative to positive) between step 3 than step 4.

Coding Scheme

- **Causal reasoning/Backwards chaining**[2] (0-2 pts per question part)
- **Coordination between equation and biological phenomenon** (0-2 pts per question part)
- **Quantitative reasoning** (0-2 pts given holistically)

[2] Russ et al. 2008

Coding Final Results



- IPLS (N=4)
- Non-IPLS physics (N=14)
- No physics at all (N=3)

Challenges in Analysis

- Most student responses were terse
- The relevant concepts in this problem were discussed differently in Neurobiology than in the IPLS course
- Qualitative reasoning was given primacy throughout Neurobiology

Conclusions

- IPLS students came in expressing more positive sentiments to interdisciplinary science learning
- Positive attitudes persisted through the semester for IPLS students
- Sentiments became more positive for non-IPLS students, but did not reach the same level as the IPLS population
- Students who have taken at least one physics course previously showed more physical reasoning on the final exam question than students who have not.

Thank You

Haley Gerardi

Nathaniel Peters

Catherine Crouch

Benjamin Geller

Chandra Turpen

Sarah Heibert Burch

Advisory Board:

Eric Brewe
Todd Cooke
Brad Davidson
Eric Kuo
Sanjay Rebello

- **Haley is presenting another part of our summer research next (CB03)**
- **Haley and I will be presenting a poster on our work at PERC on Thursday**

SWARTHMORE

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