Remote labs: making real measurements at home!

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Siena College
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The perceived problem

General Physics labs

- Cookie-cutter
- Hand-holding
- Filling out a checklist

“Make a measurement and read the value off of the screen and enter it here”

Most everyone agrees this is not the way to do labs!!!

Very preliminary work to change this at Siena started in 2016

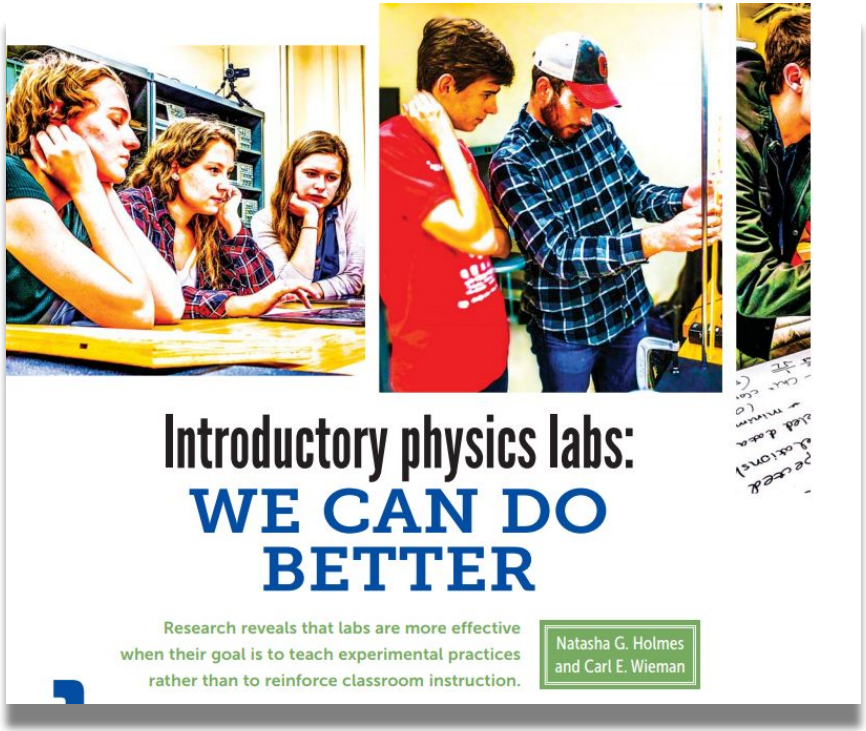
Physics Today, Jan 2018
Holmes and Weiman

Traditional labs don't do a great job reinforcing the lecture material (paraphrasing)

Summer 2019, sat with Dr. Holmes about their approach at Cornell

Fall 2019, Siena committed to inquiry-based labs in Gen Phys I w/Calculus

- ~60 students across 3 sections



Inquiry-based labs

More student agency

Less directions, less material, fewer measurements

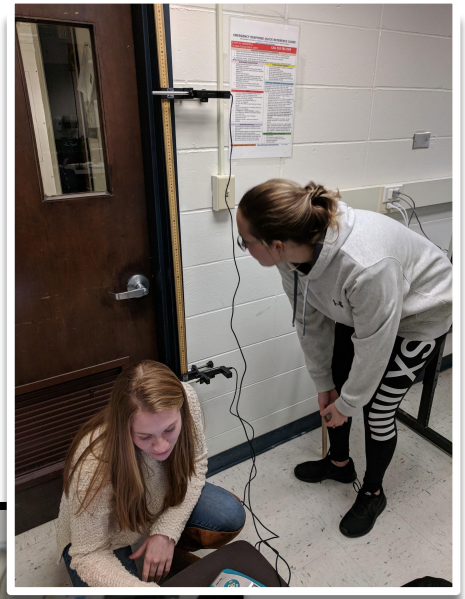
Minimize central nature of data acquisition software/hardware

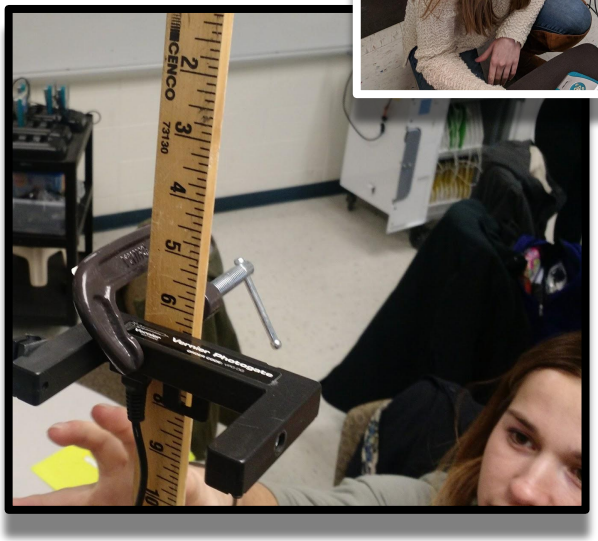
Some labs spread out over 2 weeks

- Photogates (time to fall 1 m, determing *g*)
- Simple pendulum (explore large angles)
- Hooke's law

Students use Google Colab Jupyter notebooks for analysis *and* writeup

- Jupyter was introduced in labs in 2014





Pandemic

Spring 2020 - Gen Phys II (E&M)

Didn’t have inquiry-based labs ready (Summer project)

Could we run labs at home? → not in classrooms?

Opportunity to try this out and maintain momentum!

Inspired in part by MIT Red Box

Offered to all ~60 students - ***12 volunteered*** (11 participated)

Two labs (2 weeks each)

Assembled packets during first week of remote learning and mailed out 5 (others had materials)

Made videos! Playlist here

Timing

Which hits first?

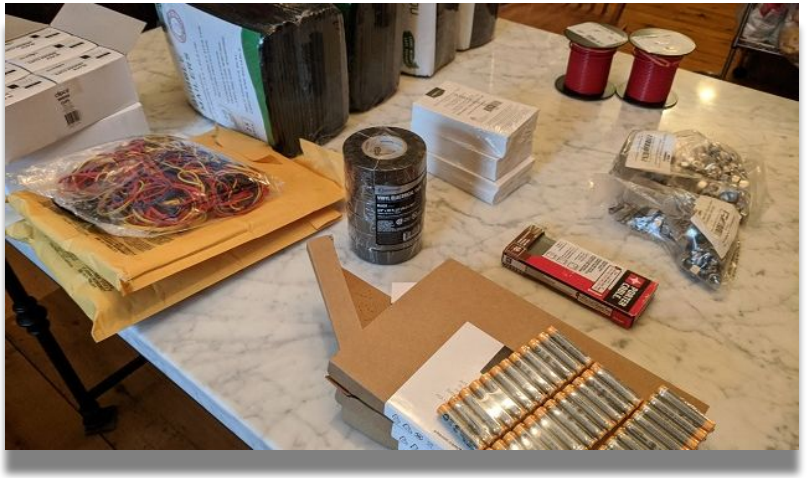
- A pendulum of length *L* striking a wall?
- An object dropped from a height *h*, where *h=L*?

What is the relationship between *h* and *L*?

Strength of electromagnet

Make an electromagnet. How strong is it?
How many nails can it pick up, as a function of windings?

Students kept online logbook (Docs) and submitted writeup and analysis with Colab



"The virtual labs have given me a fun way to learn more about the topics I've studied in physics class but from home. For the labs, we don't have accurate timing devices and other technology that you would find in a typical physics classroom, so they are much more of a challenge and push you to think like ancient physicists who did not have the technology we have today. It's a great experience and I'm looking forward to the next one!"

Noah Franz '22 (above)

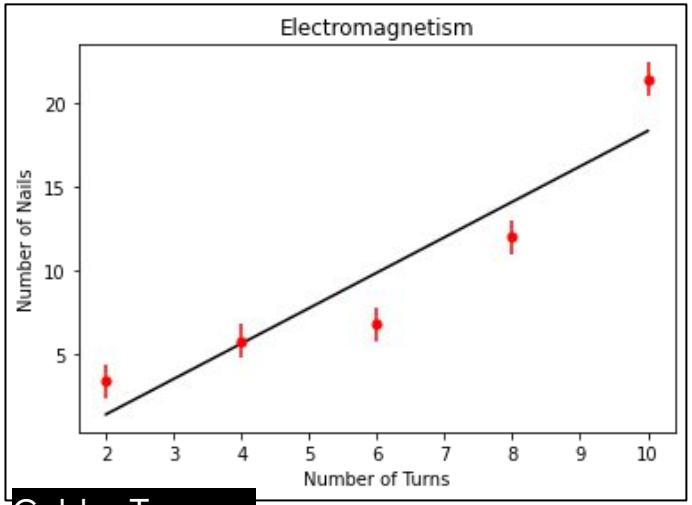
"It was fun trying to find a way to make the lab work. Although my data might not have been as precise as doing it at Siena, it made me think!"

Alexandra Robeson '22

Response was positive! (biased sample)

SCoop article

“I see physics all around my house now” (paraphrased)



Gabby Tamayo

What's next?

Outlook is unclear for these labs

I'm not teaching Gen Phys in Fall and there is either not universal support for this approach or these *particular* labs

Hopefully we can continue this approach in some form or another

Labs can be found here if anyone would like to use them - *would love to hear how it goes!*

Thanks for your time!

Backup slides

Fall 2019 - PHYS 130 lab schedule

- Week 1: Ball toss (video)
  - Uncertainties, plotting with and without python
- Week 2: Buggy
  - Students swap buggies and compare results
  - Plot x vs t, plot error bars, etc
- Week 3: Time to fall 1 meter
  - Photogates
- Week 4: Determine g
  - Photogates, different distances,
  - With and without line fitting
- Week 5-6: Pendulum lab
  - Examples of how to do a full lab report
- Week 7-8: Hooke's law
  - First week, learn how to measure
  - Second week, bring in objects
  - ***Formal lab writeup***
- Week 9-10: Moment of inertia
  - Rotational kinematics, determine relationships
- Week 11: Accident reconstruction
- Week 12: Makeup labs? Oral presentation?

2 students in each lab group, save for Buggy (3)