Transforming Introductory Physics Labs (and doing them online) Using Argument Driven Inquiry

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Outline

Link to a guide to this workshop:
`https://sfwolfphys.github.io/f2020ncsaapt.html`

XLABs Personnel

Physics

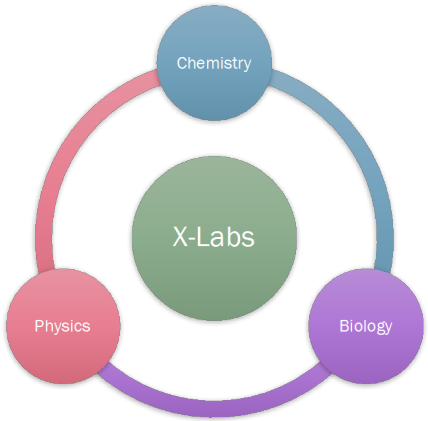
- Co-PI: Steven Wolf
- Mark Sprague

Biology

- Co-PI: Heather Vance-Chalcraft
- Co-PI: Kristine Callis-Duehl
- Taria Crenshaw

Chemistry

- Project Lead: Joi Walker
- Rosa Bell
- Kate Hosbein
- Annalisa Smith-Joyner
- Eric Eaton



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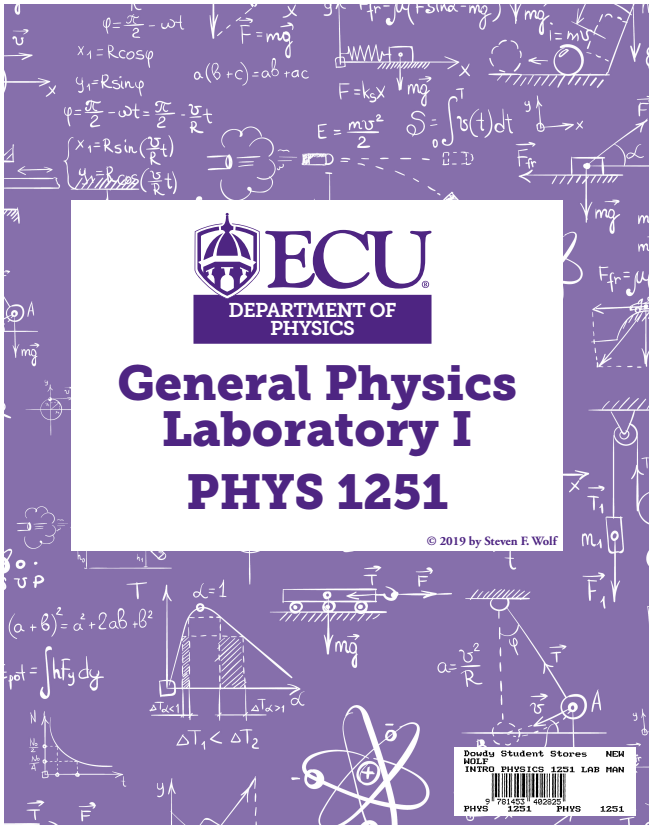
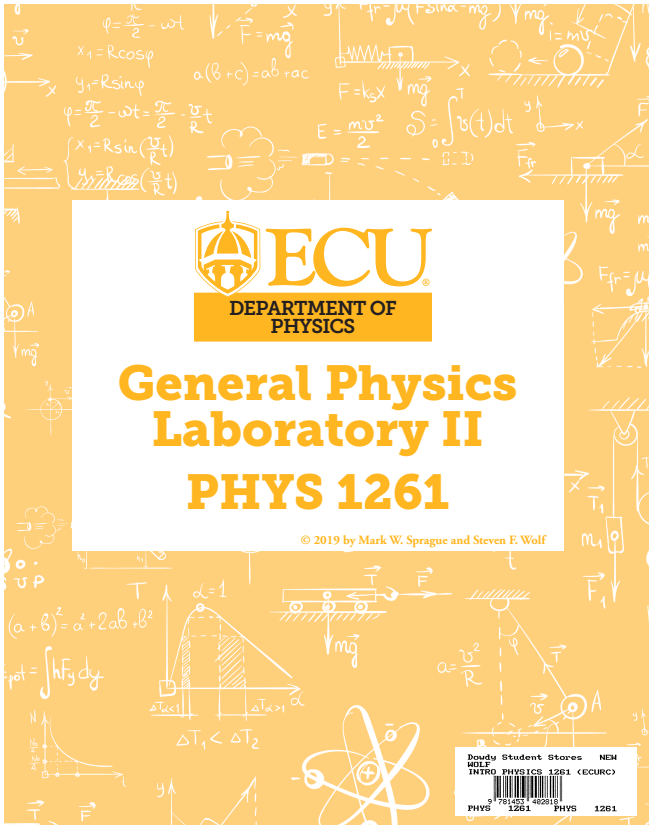
Project page:

https://bit.ly/3k3WoKf

Science Practice Focused Lab curriculum



Piloted Spring 2018



Piloted Fall 2018

What science practices?

M.J. Ford, *Science Education* **99**, 1041 (2015).

Empirical practices:

EP1	Locate information relevant to a scientific problem.
EP2	Construct a relevant/appropriate scientific question for a given problem.
EP3	Design an experiment to test a scientific question.
EP4	Apply (or know when to apply) appropriate analytical methods to examine a scientific problem.
EP5	Appraise an experimental design to identify elements and limitations and how they impact scientific findings/conclusions.
EP6	Troubleshoot technical issues.
EP7	Evaluate evidence and critique experimental designs.
EP8	Interpret basic statistics (e.g., average and SD).

What science practices?

M.J. Ford, *Science Education* **99**, 1041 (2015).

Representative practices:

RP1	Generate a hypothesis or make a prediction based on a scientific model.
RP2	Construct an argument based on evidence.
RP3	Identify additional information needed to support an argument.
RP4	Provide alternative explanations for results that may have many causes.
RP5	Integrate and apply knowledge across sub-disciplines.
RP6	Represent data in a visual form.
RP7	Interpret visual representations of data.
RP8	Construct a Data table.
RP9	Data Analysis.

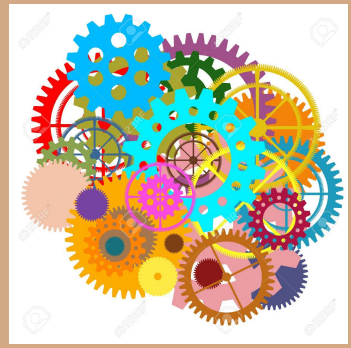
Elements of ADI

Week 1: Pre-Lab

- Students work in pairs
- Learn a new measurement or analysis technique
- Traditional lab activity

Week 2: Inquiry Investigation

- Students work in groups of four
- Students are given a scientific question to answer
- Students design an investigation and carry it out
- Investigations must be approved by TA



Elements of ADI

Week 3: Argumentation Session

- Students work in groups of four
- Students present the results of their experiment via a "poster session"
- One presenter, three travelers

After Week 3: Peer Review

- Students turn in their first draft after the argumentation session
- We use peer review tools embedded in Canvas
- Students review 3 papers while watching a peer review calibration video

Implementation at scale

Instructional Context

Labs serve both Calculus-based and Algebra-based physics lecture courses.

- **Physics 1** Typically about 400 students in approximately 25 sections managed by 8-10 TAs.
- **Physics 2** Typically about 250 students in approximately 15 sections managed by 5-6 TAs.

Implementation at scale

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Management strategies

- Course is hosted on our LMS (Canvas) - All sections as one course
- Course is set up by lab manager (MWS) - assignments, due dates, syllabus, etc.
- All artifacts are turned in online
- TAs grade using rubrics... calibration is important!

Reaction Time Lab Activity – Background

Plan:

- You will be split into groups of 2 or 3
- Your task: Complete the workshop activity on the workshop page
- I'm planning 15 minutes for this portion:
  - Guidance we give students: 30 data points
  - We also discuss mean, standard deviation, and standard error

Link to workshop page:
`https://sfwolfphys.github.io/f2020ncsaapt.html`

Argumentation Session Instructions – 15 min

Goal:

- Each group will prepare to share out briefly
- Want to give you a flavor of how this works in a class

Transition to Online Learning

Spring 2020

We had about 2 weeks to plan to finish labs. Keys to success:

- Don't forget about the physics, and your learning goals.
- Adapt, don't change.
- Get a little lucky.

Summer 2020 and beyond

We still wanted a hands on experience.

- Lab manuals were made available online
- Students purchased kits for a reasonable price

Post pandemic: We have DE students who struggle to take lab courses.

Online adaptation of ADI Elements

Week 1a and 1b: Pre-Lab

- TAs hold "office hours" at regular class time
- Students work asynchronously

Week 2a: Inquiry Investigation

- Students work in groups of four asynchronously
- Groups get proposals approved during regular class time

Online adaptation of ADI Elements

Week 2b: Argumentation Session

- Posters are power points rather than whiteboard posters
- Argumentation occurs synchronously

After Week 2b: Peer Review

- Remains unchanged

Physics 1 Online Investigations

Investigation	Topic	Guiding Question
1	1-D kinematics	Does a ball rolling on an incline have the same acceleration on the way up as it does on the way down?
2	2-D collisions	Is the collision between two marbles elastic?
3	Periodic motion	What is the nut position for which the physical pendulum small-angle period is minimum, and what is the power-law regression equation for the period of the system?

We have dropped a reaction time investigation due to our shortened semester.

Physics 1 Kit contents

Quantity	Item	Investigation(s)
1	Protractor	1
2	25 mm marble	1, 2
1	Tape measure with cm scale	1, 2, 3
1	0.6 m threded rod	3
1	Eye nut	3
3	Nuts	3
1	Door hook	3
1	1 m string	3
1	16 mm marble	2

Physics 2 Online Investigations

Investigation	Topic	Guiding Question
1	Current and resistance	Does a light bulb behave like a resistor?
2	Time varying circuits	Do two of the lab kit capacitors have the same capacitance?
3	Diffraction of light	Are hairs from different people the same diameter?

Physics 2 kit contents

Quantity	Item	Investigation(s)
1	100 Ω resistor	1
1	330 Ω resistor	1
1	100 Ω potentiometer	1
1	E10 light bulb holder	1
1	5 V E10 incandescent light bulb	1
1	Breadboard	1, 2, 3
1	Breadboard power supply	1, 2, 3
1	USB power supply cable	1, 2, 3
1	Jumper wire set	1, 2
2	Multimeters	1, 2
1	Mini screwdriver for multimeters	1, 2
5	500 mA fuses for multimeters	1, 2
4	Alligator clip leads	1, 2
1	1 MΩ resistor	2
2	100 µF capacitor	2
1	5 V, 650 nm laser module	3
1	Tape measure with cm scale	3

Thank You!

Any Questions?

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