Data Science in Intro Physics & Physical Science: Ideas from the STEMcoding Project

Prof. Chris Orban

STEMcoding
A little about me

- Computational physics
- Plasma physics
- Education research
- Ph.D. in Physics from OSU
STEMcoding Team

Prof. Chris Orban
OSU physics

Kelsey Badger
OSU data librarian

Prof. Scott Zimmerman
OSU math

Jessica Kulp
Now OSU education
(OSU physics BS grad)
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You?
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You?

Your student?
Outline

• A Brief History of the last decade of CS education
  – Including K12 perspective
• The STEMcoding Project
• Ideas!
The Problem:
Students aren’t adequately prepared to work with technology

The Debate:
What does it mean to be "prepared to work with technology"?
What should the solution look like?
Think back to 2013

- In 2013, only about 10% of high schools offered a CS class
- About ~4% of high school students taking CS before graduating high school
- Silicon valley people are self-taught
- Few browser based coding tools
2013: "What most schools don't teach"
(answer: computer science)
2013: Non-profit formed to expand computer science

Code.org co-founder Hadi Petrovi and others celebrate the launch of their non-profit in 2013
2014: President Obama codes!
America’s Math Curriculum Doesn’t Add Up

Most high-school math classes are still preparing students for the Sputnik era. Steve Levitt wants to get rid of the “geometry sandwich” and instead have kids learn what they really need in the modern era: data fluency.
Freakonomics Episode in Brief

- Economist Steve Leavitt expresses his frustration with his daughter’s algebra homework
- But he does **NOT** join the chorus calling for more CS in schools
- Instead he calls for more “data science” in schools
- He highlights an initiative at UCLA to do just that
What about higher ed?

- This is all mirrored in higher ed, including physics
- PICUP starts in 2016
- Recent push to include data skills in general education requirements
STEMcoding Project
youtube.com/STEMcoding
Hour of code activities

- 2017 release – Move the blob
- 2018 release
  - Asteroids & Lunar Lander
  - Pong & Bonk.io
  - Pi day
- 2019 release
  - Escape Velocity / Newtonian Black Holes
- 2021 release
  - Earth Day / Climate Change activity
The STEMcoding Project is designing a year long data science curriculum!

- Physical science & environmental science (& health) theme
- Emphasis on spreadsheet skills, including Excel (or Google Sheets)
2021 Hour of Code Activity: Earth Day
Step 1. Go to Google and collect climate data

To look up the typical high and low temperatures throughout the year for your location, go to Google and type "climate data [name of your city]" into the search bar. This will automatically give you climate data for your location.

The data below is shown for Columbus, OH, but you should be able to easily adapt this for your location by following the directions and modifying the program.

<table>
<thead>
<tr>
<th>Month</th>
<th>High / Low (°F)</th>
<th>Rain</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Columbus, OH 43201</td>
<td></td>
</tr>
</tbody>
</table>
http://go.osu.edu/earthdaycoding
Air Pressure vs Height
Air Pressure! (designed by Prof. Chris Orban, Ohio State U.)

It turns out nearly all smartphones (iPhones and Androids) and nearly all iPads have air pressure sensors (a.k.a. barometers). There are a couple of apps you can use to get a pressure reading. The one that seems to work best on all platforms is the Arduino Science Journal app.

**Step 0.** Download the [Arduino Science Journal](https://go.osu.edu/pressure) app.

*Note: It doesn’t make a big difference if you use a smartphone or tablet, and no iPad is required for this lab. However, if you do have an iPad, please go ahead and use it.*

**Step 1.** Open the app. Press “+” to open a new experiment. Click on the symbol in the lower right corner to edit the new experiment, and select “Pressure” at the bottom of the screen to bring up the various pressure sensors.

**Step 2.** Click on this symbol 🕒 (fourth symbol from the top). At this point your screen should look something like this...
STEMcoding Object Tracker
Track colors not objects!
Track colors not objects!
Methods to Simplify Object Tracking in Video Data

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I. INTRODUCTION

Recent years have seen an explosion of interest in analyzing the motion of objects in video data as a way for students to connect the concepts of physics to something tangible like a video recording of an experiment [1, 2]. The limitations of distance learning during the COVID-19 pandemic especially grew interest in this area because students could not attend in person lab activities, but they could analyze video data from their computers at home, which is what many instructors chose to focus on.

Generally, the goal of a student activity involving analysis of video data is to obtain the x, y position of a particular object in as many frames of the video as possible. Once obtained, this data can be used to infer velocities, acceleration and any number of other quantities like momentum or energy. A variety of software exists for students to look at individual frames Video to analyze a video where he is walking across the sidewalk [2]. In the analyzed video, Dr. Lane has a red piece of paper taped to his right shoulder. This piece of paper is the object being tracked.

In the video tutorial, Dr. Lane explains that it is important to define the “template image” of the object not at the center of the paper but rather at one of the corners so that the object tracking algorithm searches for a splotch of red next to some gray, which is the color of his shirt. With this hint, the object tracking works well and the plot of x versus time shows that Dr. Lane is walking at an approximately constant velocity as expected.

Although this is just a brief moment in the tutorial video it underscores the difficulty of what automatic object tracking is attempting to do. The background of Fig. 1, for example, has many different features that the program potentially needs to scan through as it searches for the red piece of paper.
Other fun ideas

• Multi-year solar panel data
• Randomly generated star fields
  - Random number generator → csv file
Activity Links

Earth Day
go.osu.edu/earthdaycoding

Air Pressure
go.osu.edu/airpressure

Object Tracker
go.osu.edu/objecttracker
works best w/ Chrome or Edge

go.osu.edu/objecttracker-guide
How you can help!

- Join the STEMcoding monthly email list and/or slack
  - Email orban@physics.osu.edu
- Undergrad projects?
- Email BAD figures to orban@physics.osu.edu
- NSF Broader Impact
- Invite me to speak to local AAPT chapters via zoom!
- Help us use ChatGPT?
Questions?

orban@physics.osu.edu

youtube.com/STEMcoding

Monthly email list:

u.osu.edu/stemcoding