Engineers Code:

re-usable, open educational modules for engineering undergraduates

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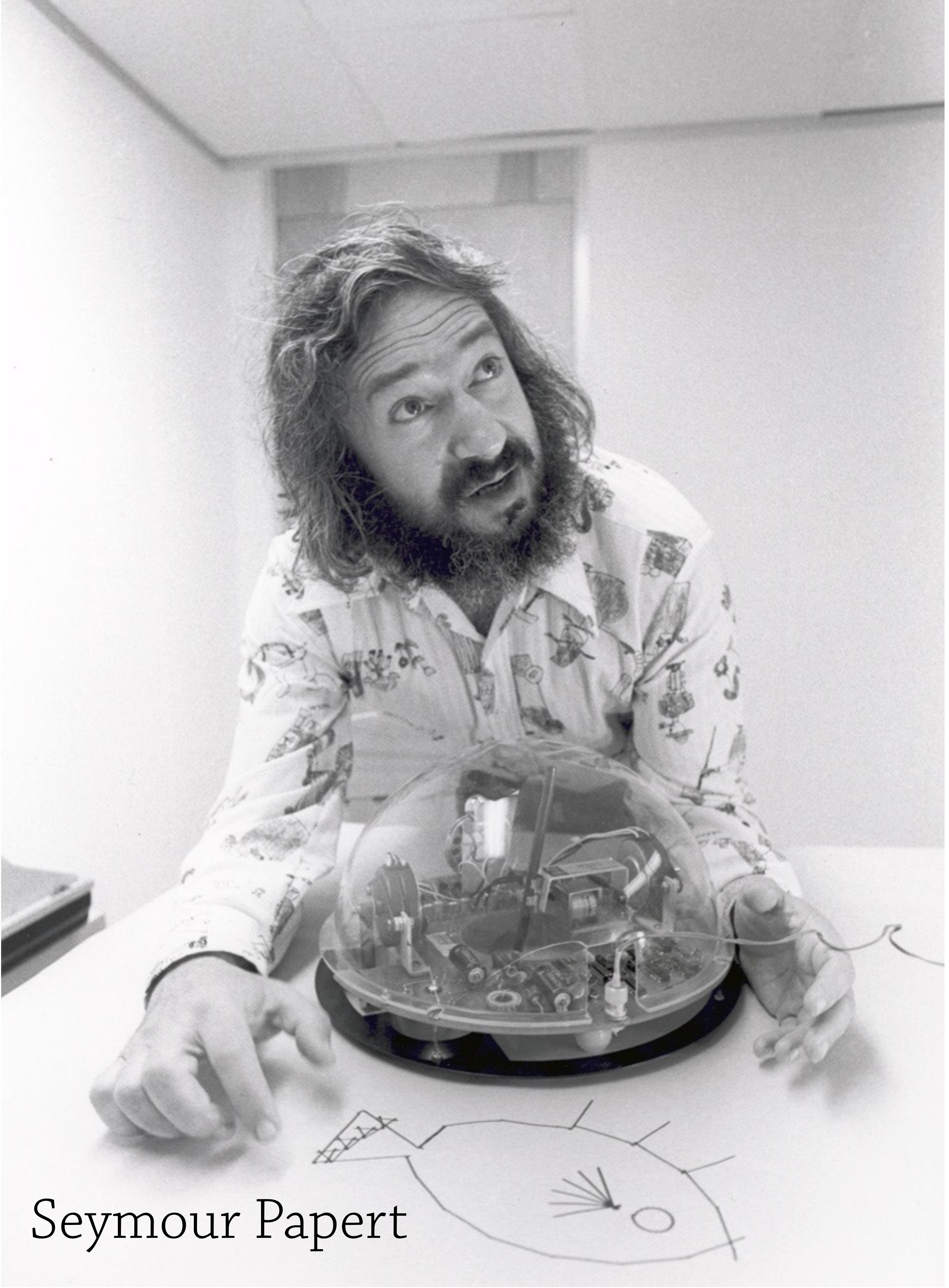
Key concepts and design principles

1. idea of "computable content"
2. open pedagogy
3. modularization
4. harnessing "worked-example effect"
5. f2f active learning with live coding
6. learners documenting their work

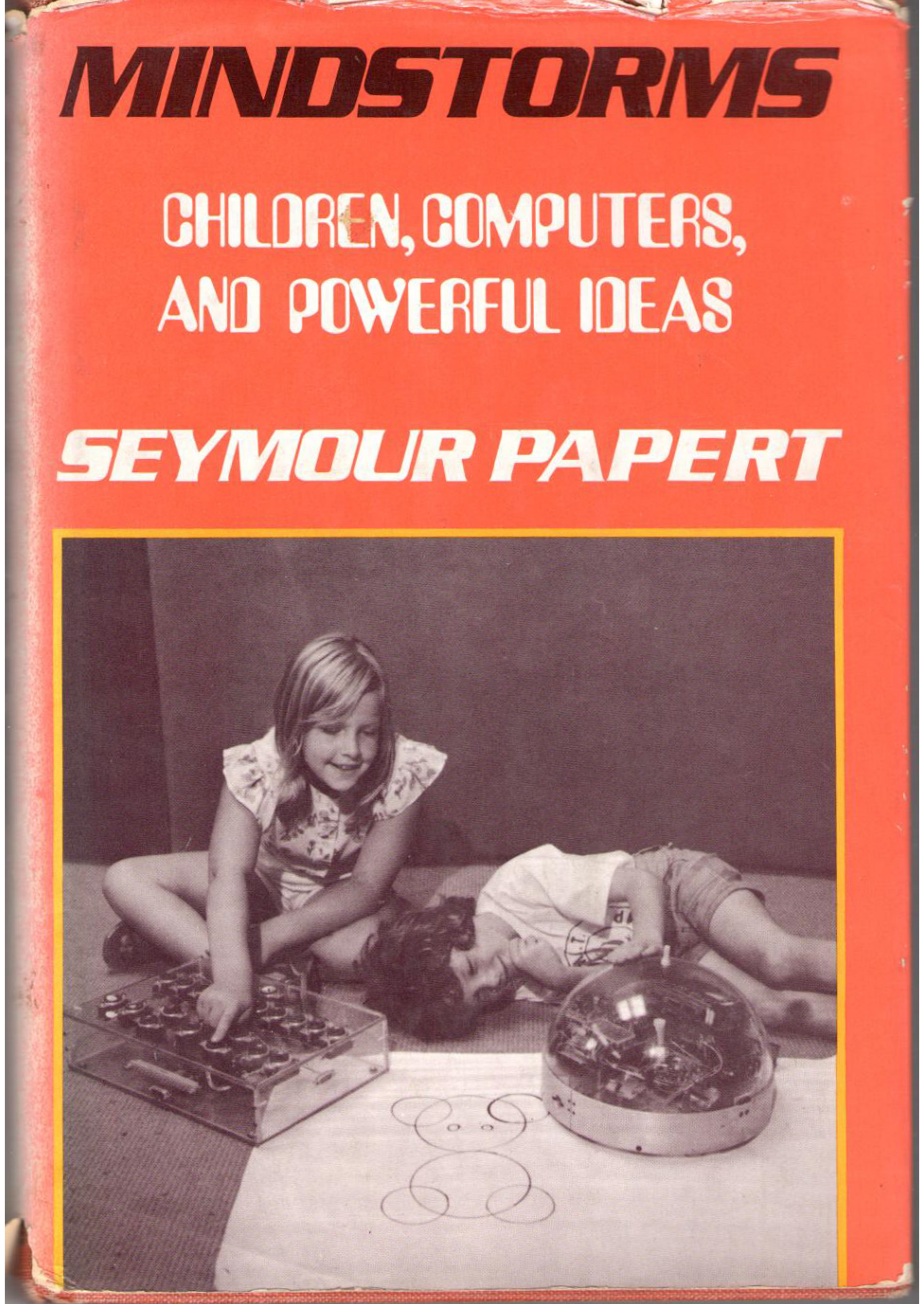
Open education

- Open Ed movement was inspired by free & open source software (FOSS).
- F*eatures missed*: open development, networked collaboration, community, value-based framework…
- **OS ethics and practices: put computing at the center of engineering education**



Seymour Papert

Computational Thinking, Computational Learning



In most cases, although the experiments have been interesting and exciting, they have failed to make it because they were too primitive. Their computers simply did not have the power needed for the most engaging and shareable kinds of activities. Their visions of how to integrate computational thinking into everyday life was insufficiently developed. But there will be more tries, and more

“Mindstorms” (1980), p. 182

A few talked about the computer as a teaching machine.

This book too poses the question of what will be done with personal computers, but in a very different way. I shall be talking about how computers may affect the way people think and learn. I begin to characterize my perspective by noting a distinction between two ways computers might enhance thinking and change patterns of access to knowledge.

— Seymour Papert, “*Mindstorms*” (1980)

The killer app: Jupyter

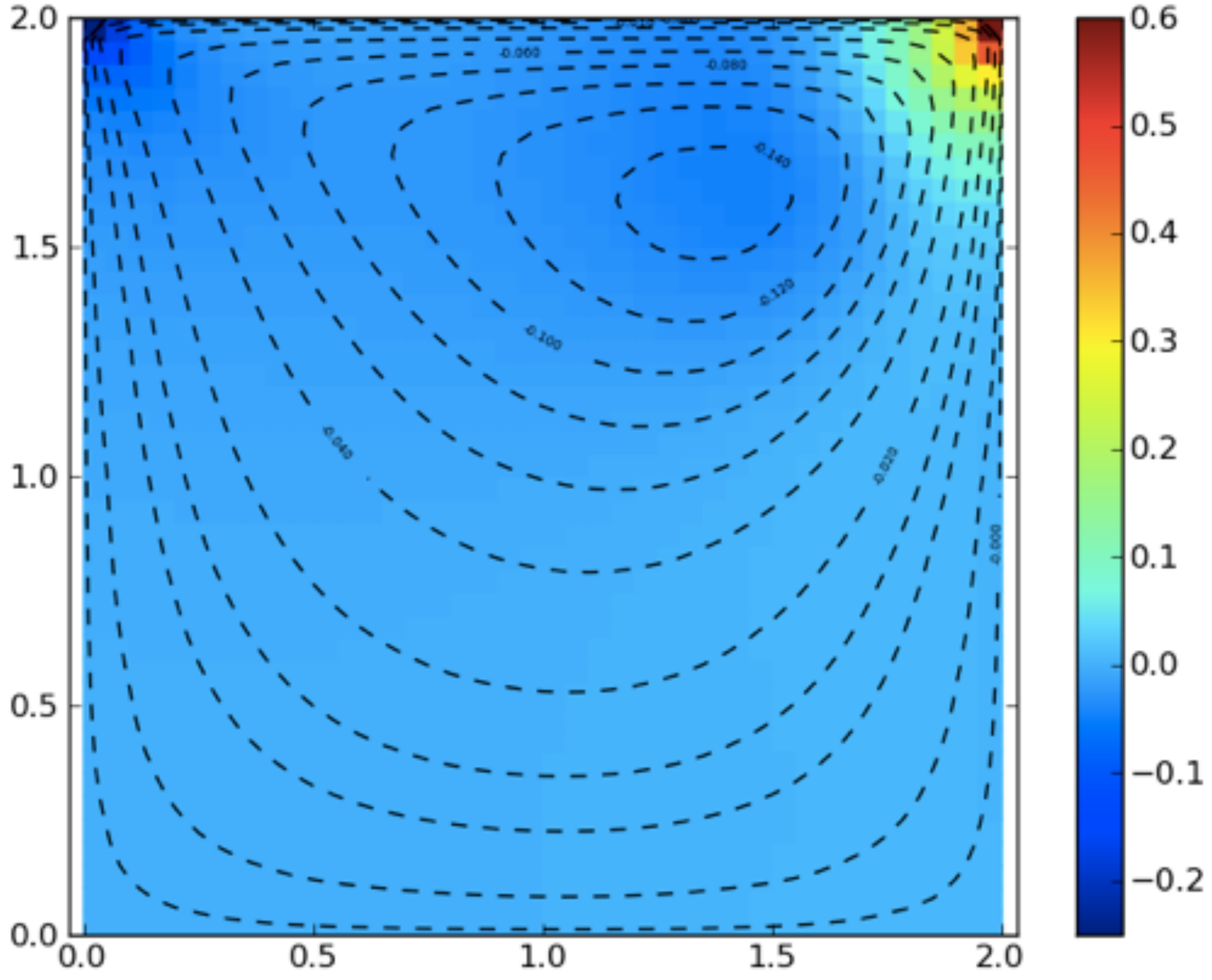
A new genre of open educational resources (OER).

Computable content

Educational content made powerfully interactive via compute engines in the learning platform.

Lorena A. **Barba group**

CFD Python: 12 steps to Navier-Stokes



Cavity flow solution at Reynolds number of 200 with a 41x41 mesh.

Posted on 07.22.2013

Lessons

- Quick Python Intro
- Step 1
- Step 2
- CFL Condition
- Step 3
- Step 4
- Array Operations with NumPy
- Step 5
- Step 6
- Step 7
- Step 8
- Defining Function in Python
- Step 9
- Step 10
- Optimizing Loops with Numba
- Step 11
- Step 12

https://github.com/barbagroup/CFDPython

Engineers Code: re-usable computing modules for undergraduate engineering

Module 1:
Get data off the ground

Learn to interact with Python and handle data with Python.

lessons:

1. Interacting with Python
2. Play with data in Jupyter
3. Strings and lists in action
4. Play with NumPy arrays
5. Linear regression with real data

Module 2:
Take off with stats

Hands-on data analysis using a computational approach and real-life applications.

lessons:

1. Cheers! Stats with beers
2. Seeing stats in a new light
3. Lead in lipstick
4. Life expectancy and wealth

Module 3:
Fly at changing systems

Tackling the dynamics of change with computational thinking.

lessons:

1. Catch things in motion
2. Step to the future
3. Get with the oscillations
4. Bird's-eye view of mechanical vibrations

Example:

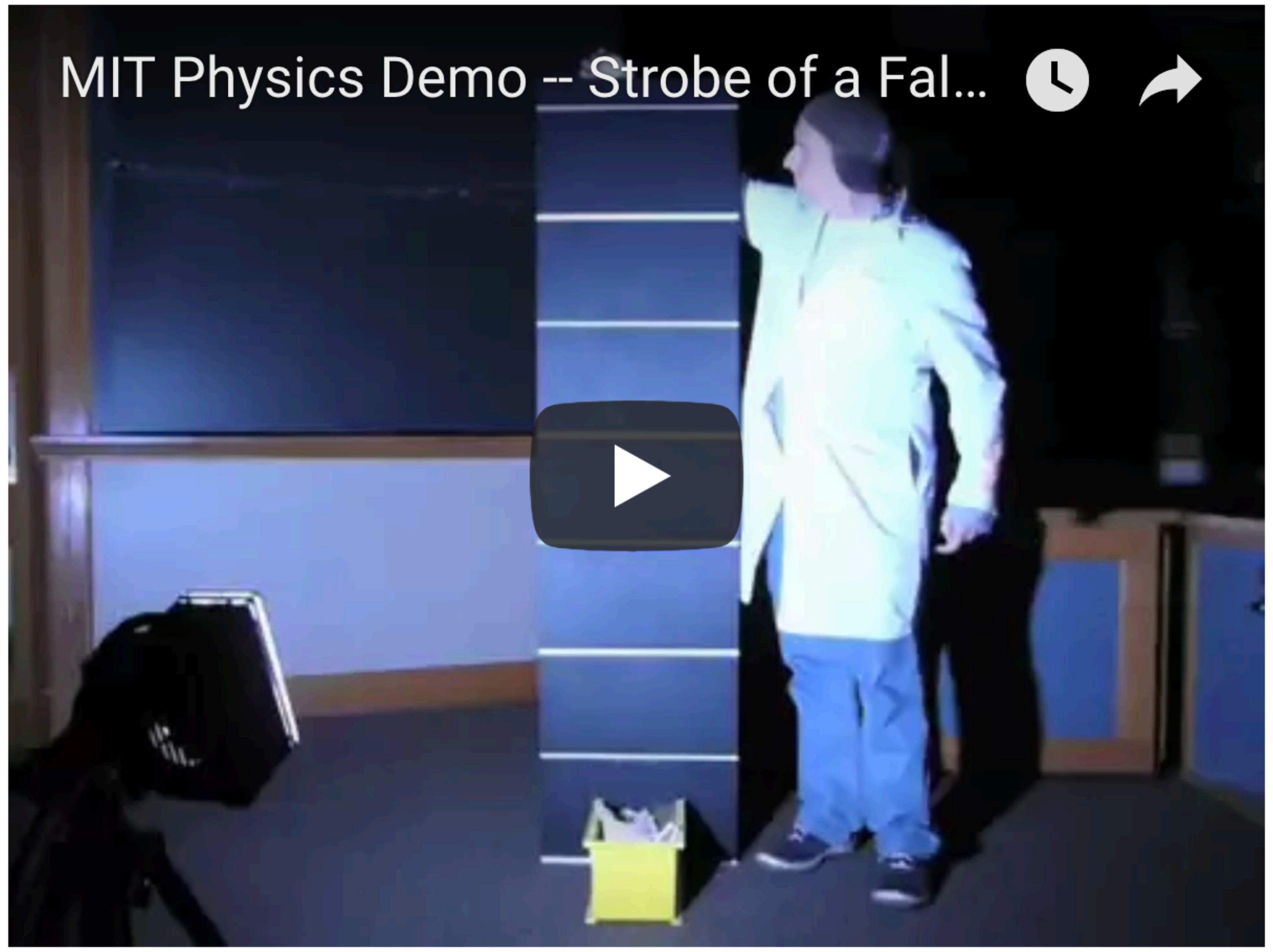
http://go.gwu.edu/engcomp3lesson1

Acceleration of a falling ball

Let's start at the beginning. Suppose you want to use video capture of a falling ball to *compute* the acceleration of gravity. Could you do it? With Python, of course you can!

Here is a neat video we found online, produced over at MIT several years ago [1]. It shows a ball being dropped in front of a metered panel, while lit by a stroboscopic light. Watch the video!

In [1]:
```
from IPython.display import YouTubeVideo
vid = YouTubeVideo("xQ4znShlK5A")
display(vid)
```

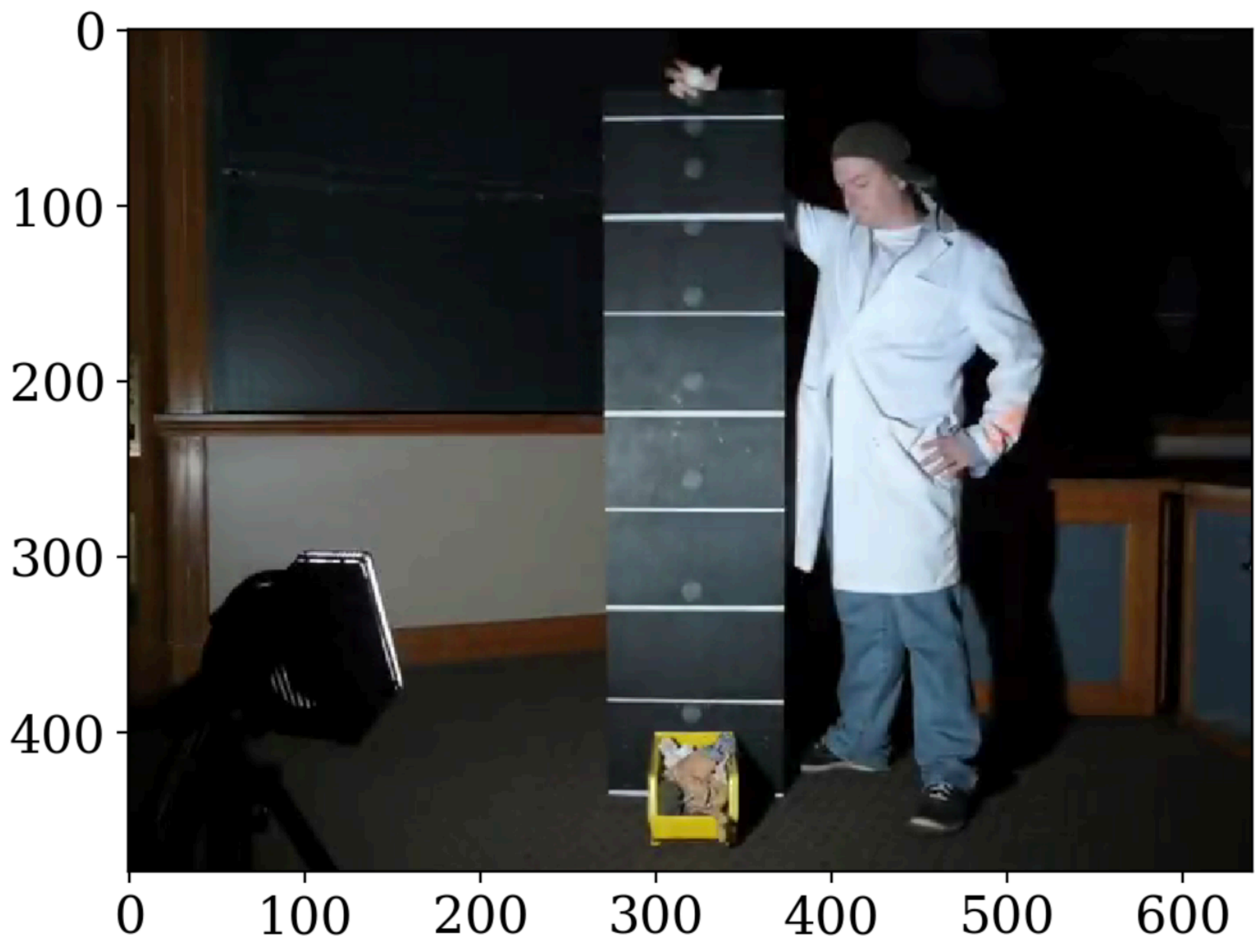


In [11]:
```python
fig = pyplot.figure()

pyplot.imshow(image, interpolation='nearest')

coords = []
def onclick(event):
    '''Capture the x,y coordinates of a mouse click on the image'''
    ix, iy = event.xdata, event.ydata
    coords.append([ix, iy])

connectId = fig.canvas.mpl_connect('button_press_event', onclick)
```



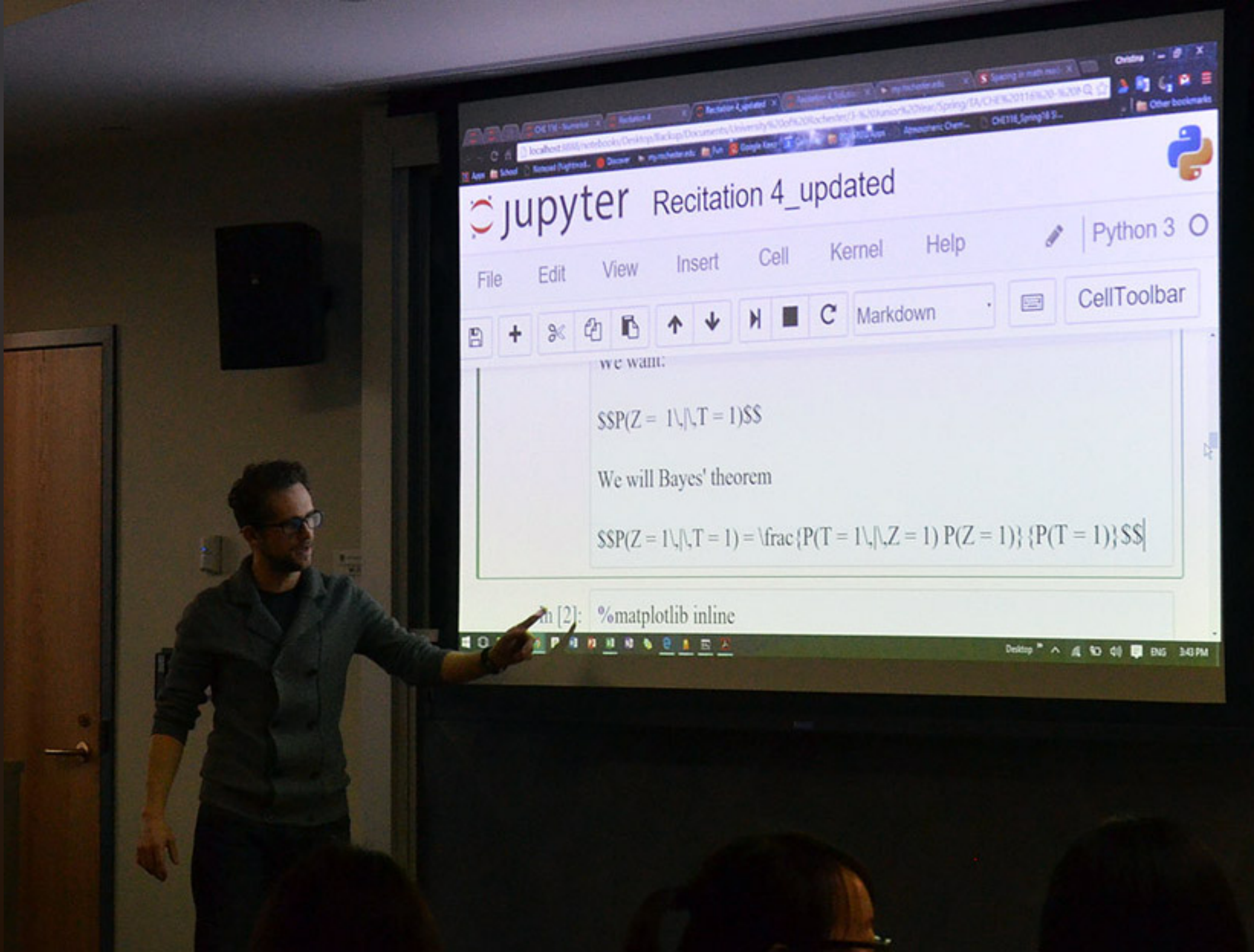
In [12]:
```python
coords
```

Out[12]:
```
[[270.77840909090912, 53.306818181818073],
 [270.77840909090912, 107.85227272727263],
 [272.07711038961043, 163.6964285714285],
 [272.07711038961043, 219.54058441558436],
 [272.07711038961043, 274.08603896103892],
 [272.07711038961043, 328.63149350649348],
 [273.37581168831173, 383.17694805194799],
 [274.67451298701303, 435.125]]
```

How to develop lessons:

1. Break it down into small steps
2. Chunk small steps into bigger steps
3. Add narrative and connect
4. Link out to documentation
5. Interleave easy exercises
6. Spice with challenge questions/tasks
7. Publish openly online!

In class…


jupyter
Recitation 4_updated
Python 3
File
Edit
View
Insert
Cell
Kernel
Help
Markdown
CellToolbar
We want:
$$P(Z = 1\,|\,T = 1)$$
We will Bayes' theorem
$$P(Z = 1\,|\,T = 1) = \frac{P(T = 1\,|\,Z = 1) P(Z = 1)}{P(T = 1)}$$
In [2]:
%matplotlib inline

Active learning increases student performance in science, engineering, and mathematics

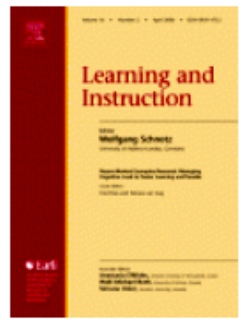
Scott Freeman[a,1], Sarah L. Eddy[a], Miles McDonough[a], Michelle K. Smith[b], Nnadozie Okoroafor[a], Hannah Jordt[a], and Mary Pat Wenderoth[a]

[a]Department of Biology, University of Washington, Seattle, WA 98195; and [b]School of Biology and Ecology, University of Maine, Orono, ME 04469

Edited* by Bruce Alberts, University of California, San Francisco, CA, and approved April 15, 2014 (received for review October 8, 2013)

Pedagogy: worked-example effect

Learning and Instruction
Volume 16, Issue 2, April 2006, Pages 87-91



Guest editorial

Optimising worked example instruction: Different ways to increase germane cognitive load ☆

Fred Paas [a, b], Tamara van Gog [a]

Educational Psychology
Vol. 30, No. 3, May 2010, 349–367

Routledge
Taylor & Francis Group

Worked example effects in individual and group work settings

Endah Retnowati, Paul Ayres* and John Sweller

School of Education, University of New South Wales, Sydney, New South Wales, Australia

Journal of Educational Psychology
2015, Vol. 107, No. 3, 689–704

0022-0663/15/$12.00 http://dx.doi.org/10.1037/edu0000018

The Worked Example Effect, the Generation Effect, and Element Interactivity

Ouhao Chen, Slava Kalyuga, and John Sweller
University of New South Wales

Educational Psychologist
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/hedp20

The Expertise Reversal Effect

Slava Kalyuga , Paul Ayres , Paul Chandler & John Sweller
Published online: 08 Jun 2010.

GW | Online

Courses  LorenaBarba

Get Data Off the Ground with Python

EngComp1 #EngineersCode

http://go.gwu.edu/engcomp1

Start Date:	Duration:	Price:	
Feb 22, 2018	N/A	Free	You are enrolled in this course

Course Description

Organization: GW

Jupyter Notebook Viewer XBlock

1. Write “Jupyter-first” course
2. Publish notebooks online (e.g., GitHub)
3. Add content to Open edX via the XBlock
   a. use notebook URL (dynamic content)
   b. break long notebook into “unit-sized” parts using ‘start’ & ‘end’ strings
   c. get pretty code formatting, plots, embedded images

Bookmarks Search

Linear regression with real data > Earth temperature over time > Plot the data

Previous Next

Plot the data

Bookmark this page

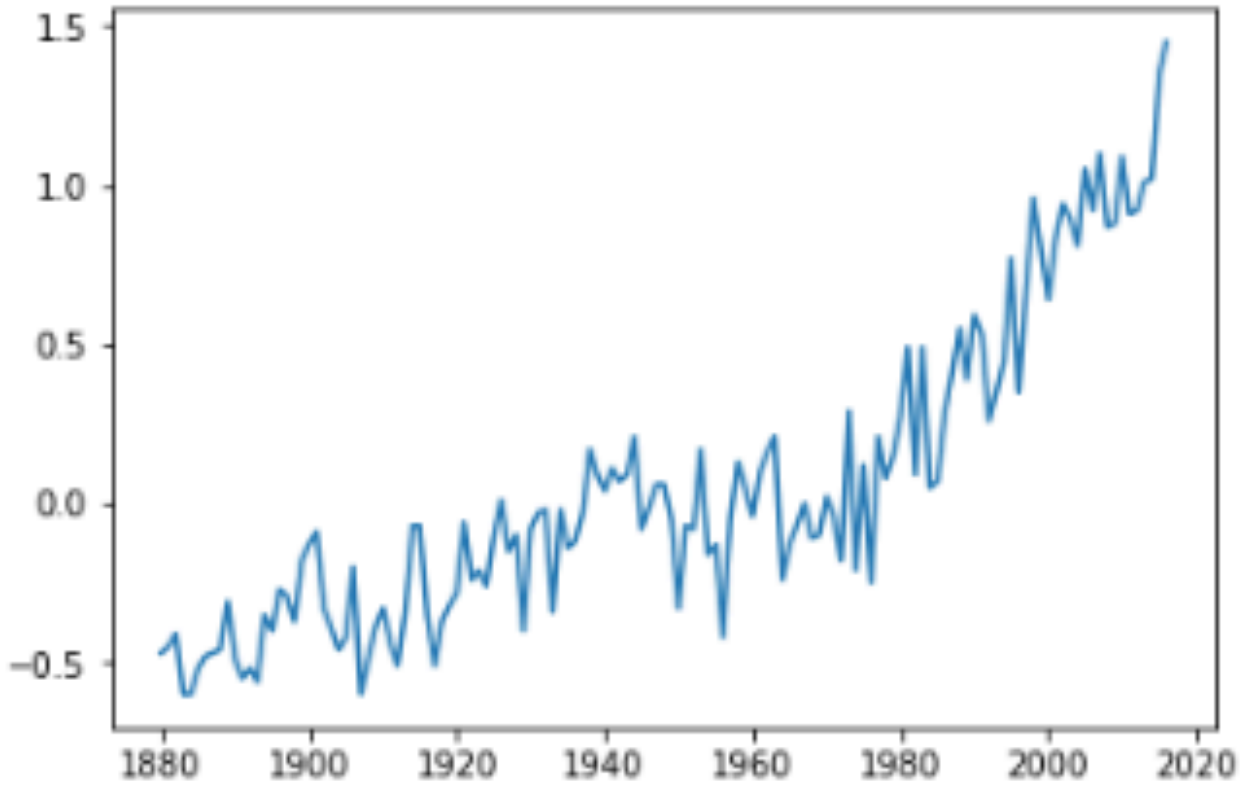
Step 2: Plot the data

Let's first load the **Matplotlib** module called `pyplot`, for making 2D plots. Remember that to get the plots inside the notebook, we use a special "magic" command, `%matplotlib inline`:

In [4]:
```
from matplotlib import pyplot
%matplotlib inline
```

The `plot()` function of the `pyplot` module makes simple line plots. We avoid that stuff that appeared on top of the figure, that `Out[x]: [< ...>]` ugliness, by adding a semicolon at the end of the plotting command.

In [5]:
```
pyplot.plot(year, temp_anomaly);
```



Graded Jupyter Notebook XBlock

1. Write assignment using `nbgrader`
2. Upload `requirements.txt` with dependencies: XBlock builds course image
3. Upload instructor notebook, enter settings
4. Students download assignment & solve
5. Uploaded assignment:
    a. launches Docker container with requirements
    b. auto-grading gives student a score report, writes into gradebook

Assessment 1: strings

Bookmark this page

Graded Jupyter Notebook

Instructions

This is the first assessment for the section "Play with data in Jupyter," dealing with string manipulations.

Download the notebook, work on it in your local Jupyter install or in a cloud service, then upload your solved notebook here to get it graded automatically. The notebook includes three exercises.

Be sure to follow the instructions to the letter!

You have unlimited submissions—just upload a new notebook and it will get auto-graded and your score updated.

Download Student Notebook

Student Upload

Notebook Name: engcomp1hw1.ipynb

Choose File no file selected

Upload

Computational Thinking for STEM

1. Data practices
2. Modeling and simulation practices
3. Computational problem-solving
4. Systems-thinking practices

Weintrop, David, et al. "Defining computational thinking for mathematics and science classrooms." Journal of Science Education and Technology 25.1 (2016): 127-147. https://doi.org/10.1007/s10956-015-9581-5