Jupyter in UC Berkeley's Data Science Education Program

Elaine Angelino and Sam Lau

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A guided tour

- Publicly available information distributed across many web pages and GitHub repositories running a live suite of data science courses

- Designed for and by many UC Berkeley students, instructors, other teaching / support staff

Who is this presentation for?

- Diverse folks thinking about data science education, using Jupyter notebooks in the classroom, and/or deploying and scaling JupyterHub

- Designed for people who don't have accounts on **data8.berkeley.edu**

What is in this presentation?

- An overview of the UC Berkeley's new data science education program
- Pointers to current course materials distributed as Jupyter notebooks
- An overview of the live JupyterHub-based infrastructure
- Hopefully, lots of materials to explore, fork, and hack on

Some dependencies

- All course content and software is viewable online
- You'll need a **Git** if you want to clone or fork this content
- Course content is distributed as Jupyter notebooks that have several Python dependencies
  - **Python 3**
  - **Jupyter**
  - **datascience**

DATA 8: Foundations of Data Science

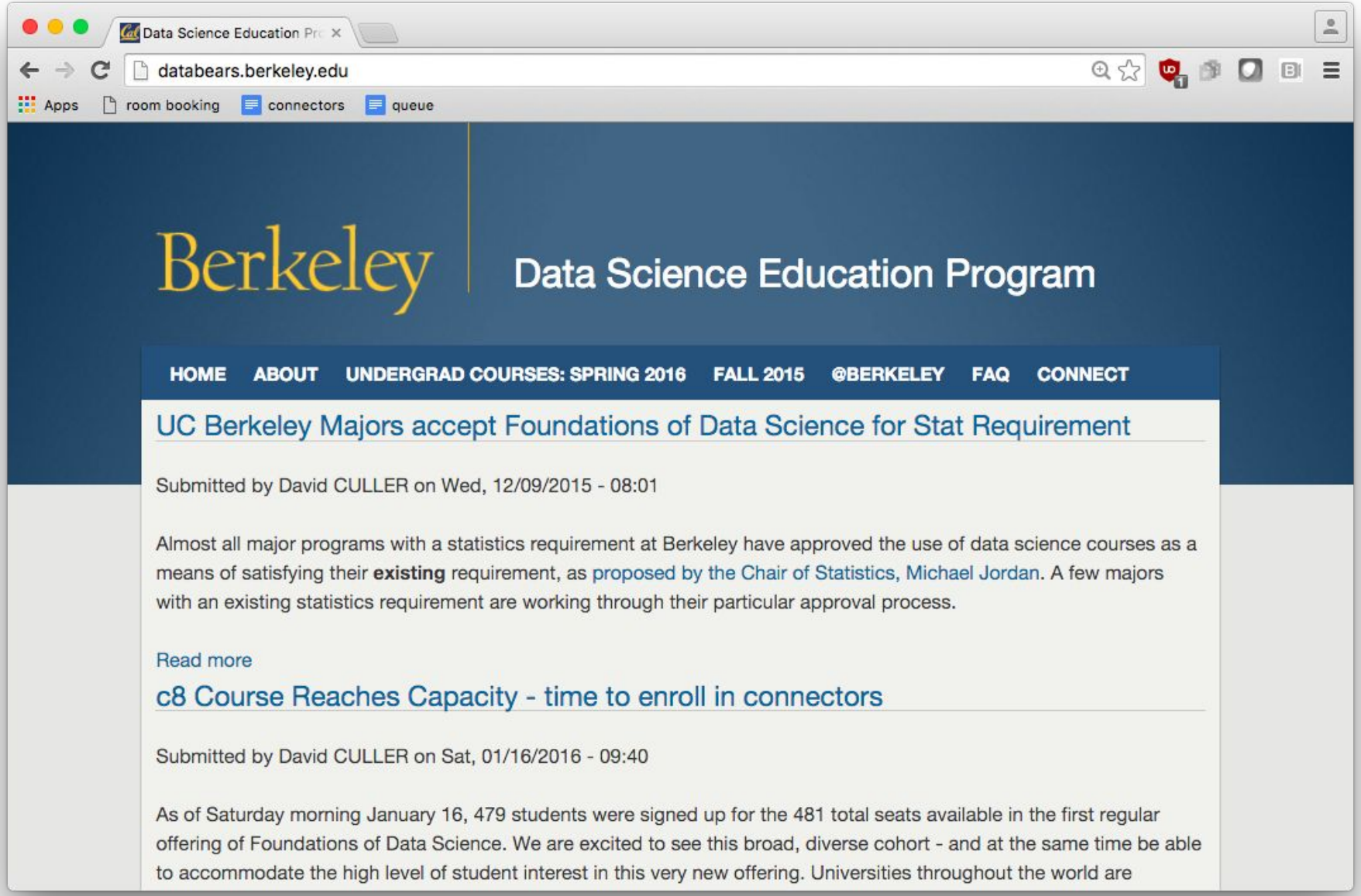
DATA 8: First day of class, Spring 2016

Course overview

- Teaches computational and inferential (statistical) thinking through interaction with real data
- Pilot run in Fall 2015 with about 80 students
- Current Spring 2016 enrollment at about 470 students
- Three 50 min lectures & 2 hour computer lab every week

Broader context

databears.berkeley.edu



Broader context

databears.berkeley.edu

- This is all new, fast-moving, growing, & the intention is to keep growing (up to 3000 DATA 8 students / semester)
- Complemented by a suite of connector courses teaching diverse subjects through the lens of data science
- DATA 8 course is meant to be a foundation for advanced courses to be seeded across the university
- See the report on **Data Sciences @ Berkeley: The Undergraduate Experience**

Course design requirements

- Must be accessible to all incoming first-year students
- Assume no computer science background and only high school algebra
- Students interact immediately with data programmatically
- Can’t assume all students have personal computers
- Can't require students to figure out a local installation
- Provide a platform (technical & intellectual) that students can build on throughout their college careers

Implementation highlights

- Jupyter notebooks + JupyterHub support a solution satisfying all design requirements

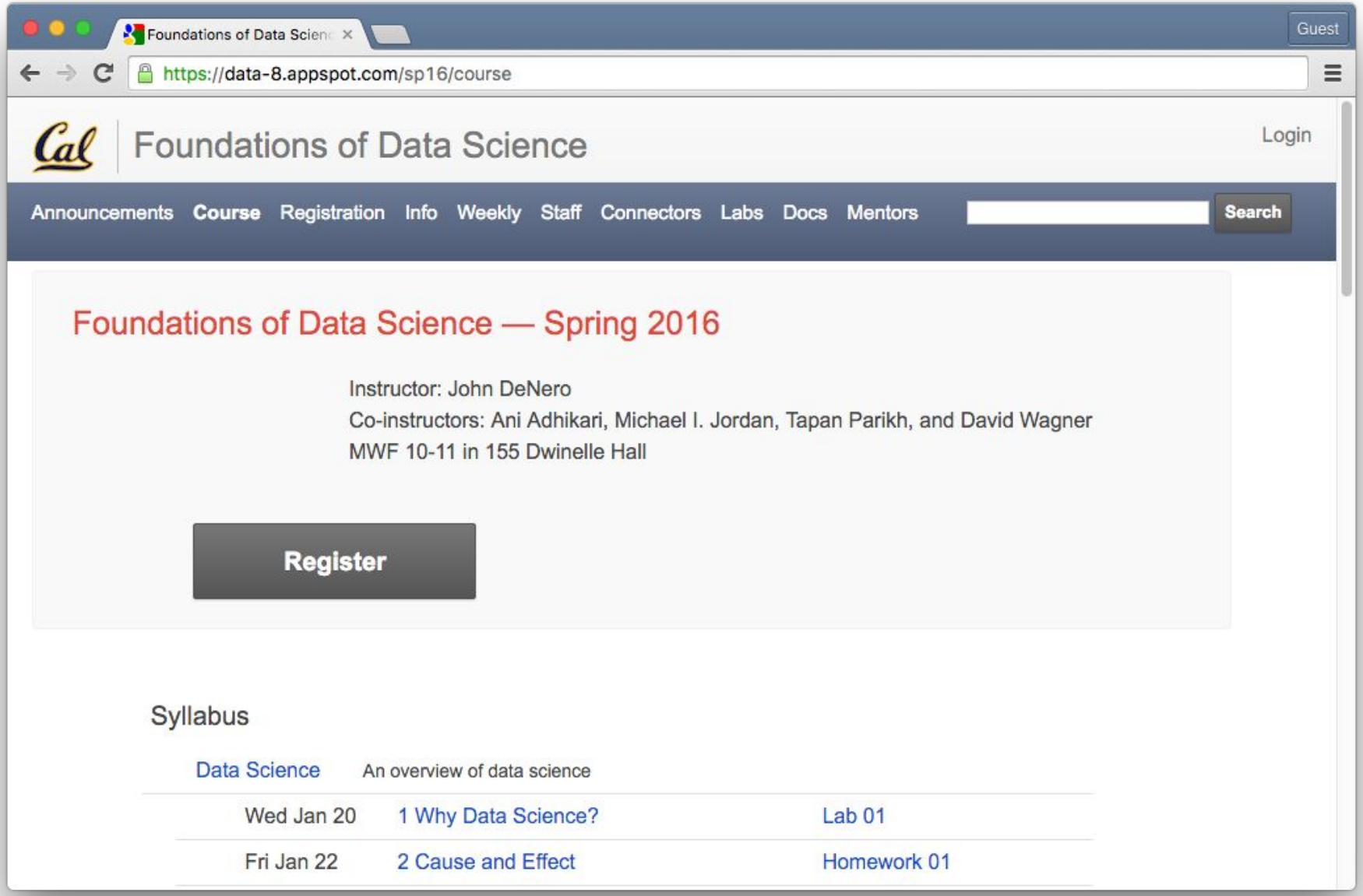
- Why Jupyter notebooks?
  - Provide a natural environment for introducing data science skills to students
  - Let students develop an explicit computational narrative with data
  - Interactive substrate for distributing course content

Implementation highlights

- Jupyter notebooks + JupyterHub support a solution satisfying all design requirements

- Why JupyterHub?
  - Multi-user server for Jupyter notebooks can support many users (students, instructors, teaching staff)
  - Enables browser-based interface to computation in the cloud
  - Students only need a browser to start programming, interacting with data, creating a visible record of their analytical steps

Course website: data8.org



Course website: **data8.org**

Syllabus and links to lecture videos

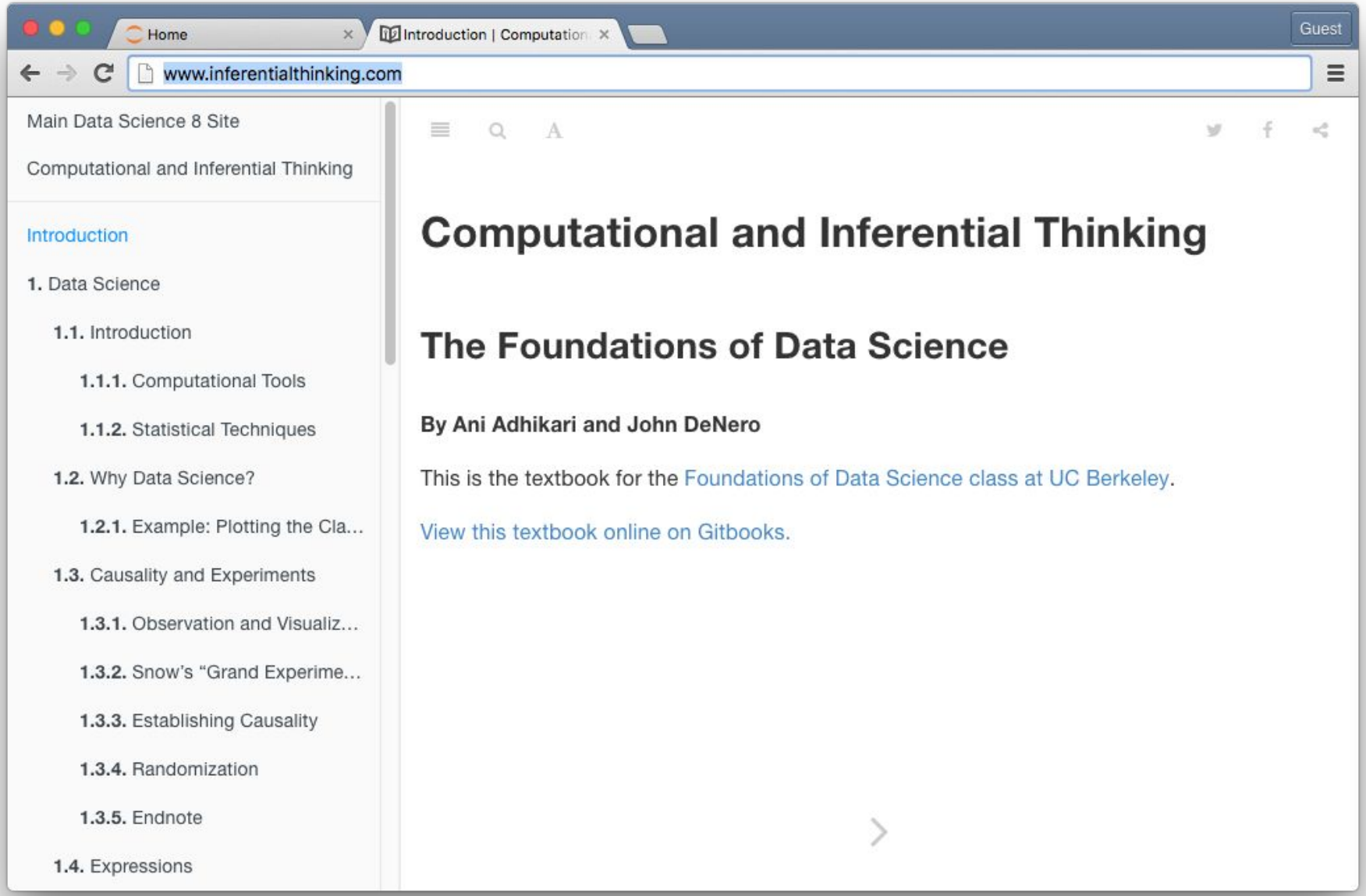
- An overview of data science
- Using Python to manipulate info in table data structures
- Interpreting and exploring data through visualizations
- Sampling: Understanding the behavior of random selection
- Making predictions from data
- Inference: Reasoning about populations by computing over samples
- Models: Making assumptions & exploring their consequences

Course website: data8.org

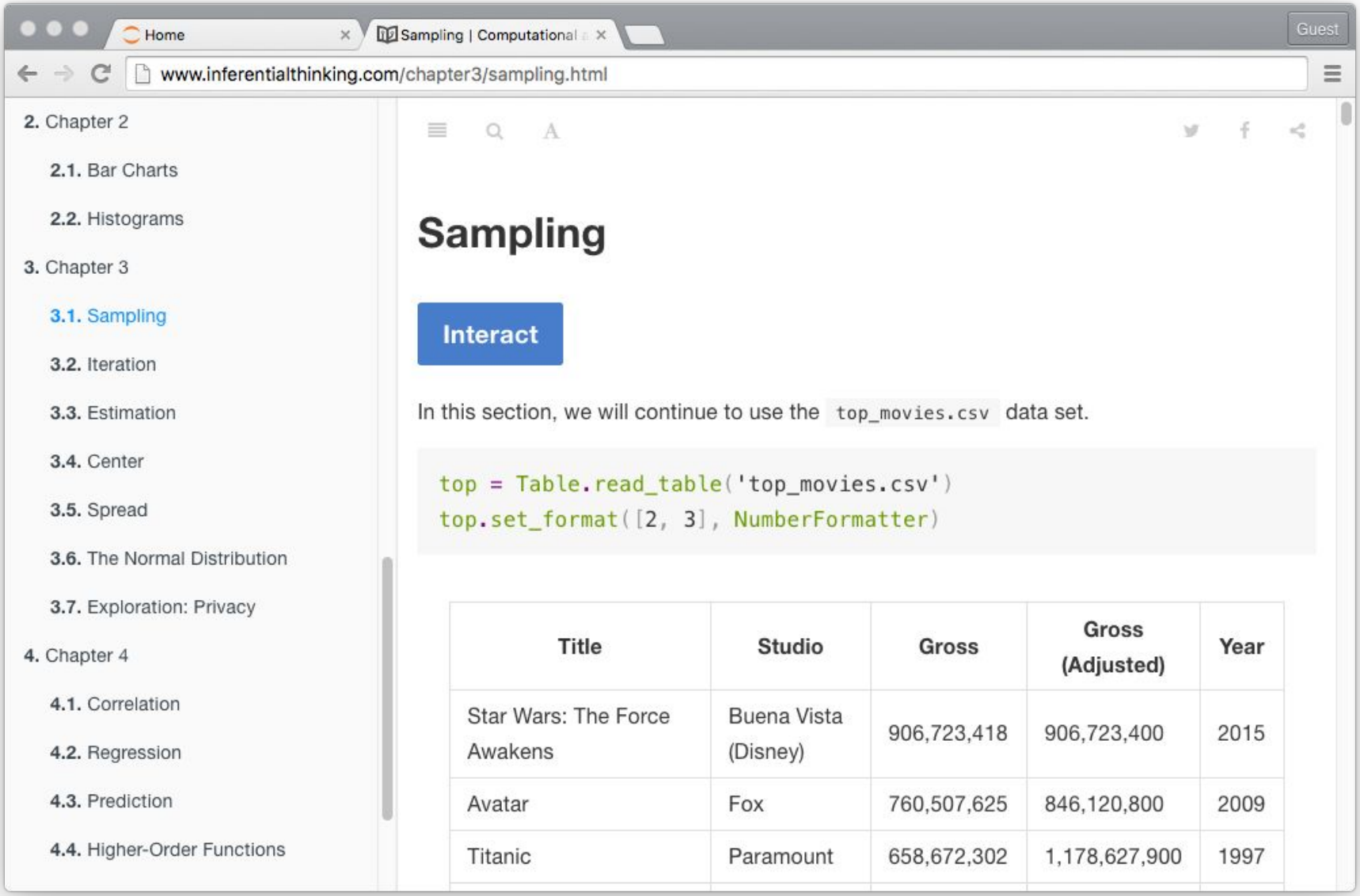
- data8.org is primarily a student-facing website and its links to content such as computer lab assignments will **not** work for anyone who doesn't have a course account

- We'll show you:
  - What students see and interact with
  - How links to interactive materials work for students
  - How to find the source materials hosted across many GitHub repositories at https://github.com/data-8

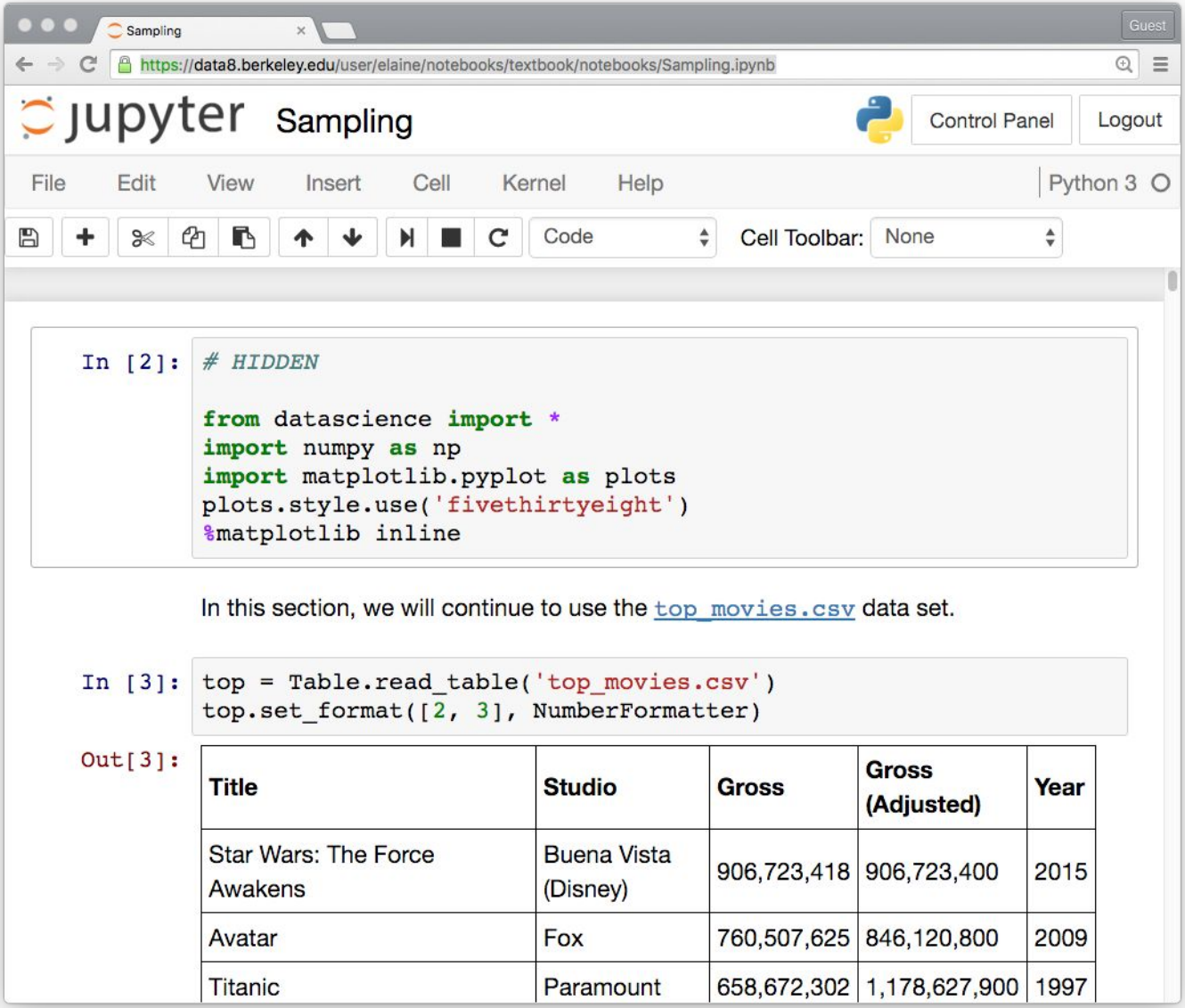
Online textbook: www.inferentialthinking.com



Most sections of the online textbook begin with a big blue Interact button (example section)



When a student clicks the Interact button, they're redirected to an interactive Jupyter notebook!



Link to the same notebook in Binder:

http://bit.ly/sampl-nb

What’s going on?

- First, we'll explain where the source material is
- Second, we'll explain the Interact button

The textbook is hosted in a GitHub repo

```
git clone https://github.com/data-8/textbook.git
```

- Most of the underlying source material for the textbook is written in Jupyter notebooks (**example notebook**)
- **GitBook** allows us to **write and organize chapters using Markdown**
- Conveniently, **Markdown** allows arbitrary HTML inline
- Convert notebook to HTML snippet using **nbconvert**
- Include that HTML in the .md file (**example Markdown**)

The Interact button

- An Interact button in the textbook (**example section**) is a link like this:

  ```
  http://data8.berkeley.edu/hub/interact?
      repo=textbook&
      path=notebooks/top_movies.csv&
      path=notebooks/Sampling.ipynb
  ```

- Uses **DS8-Interact**, a side server for the DATA 8 JuypterHub deployment that copies remote notebooks and other files into user accounts

  ```
  git clone https://github.com/data-8/DS8-Interact.git
  ```

Interact links distribute content to students

- Not just for the online textbook
- This link-based system for loading content also works for whole directories and anything that can be checked in
- Used for distributing labs, homeworks, projects, etc.
- Not just for the DATA 8 course
  - Also being used by the connector courses

Our JupyterHub deployment

Origin story

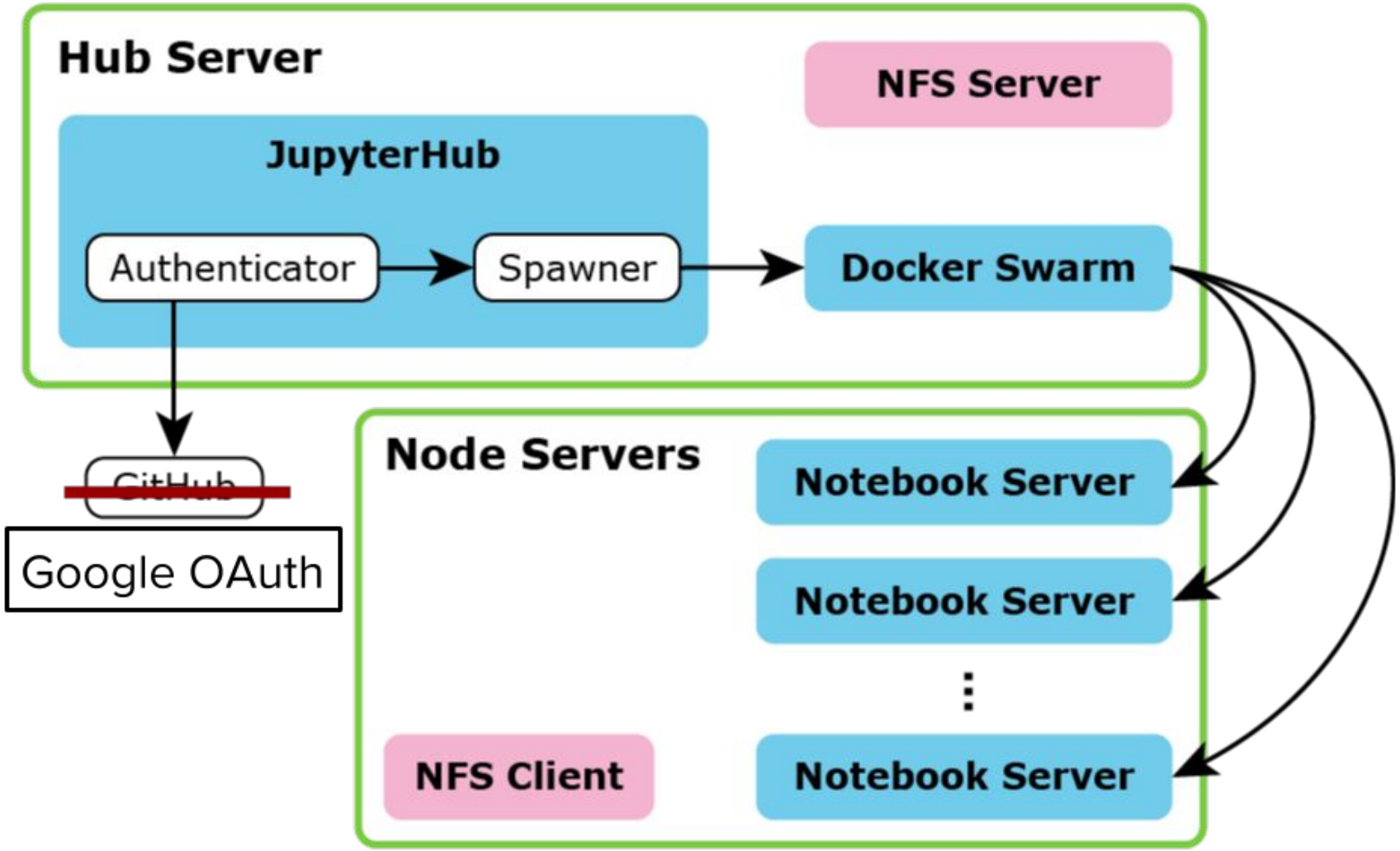
- We were about to level out a new basement to give students computers with Jupyter installed...
- ...until we discovered that **Jessica Hamrick** had deployed JupyterHub to the cloud for a UC Berkeley cognitive science class of 220 students
- We thought we could do it too!

Our JupyterHub deployment

```
git clone https://github.com/data-8/jupyterhub-deploy.git
```

- **Our deployment** is based on Jessica Hamrick's **jupyterhub-compmodels-deploy**
- See Jess's blog post at Rackspace on **Deploying JupyterHub for Education** and also the README at **jupyterhub-compmodels-deploy** for details

Our JupyterHub deployment

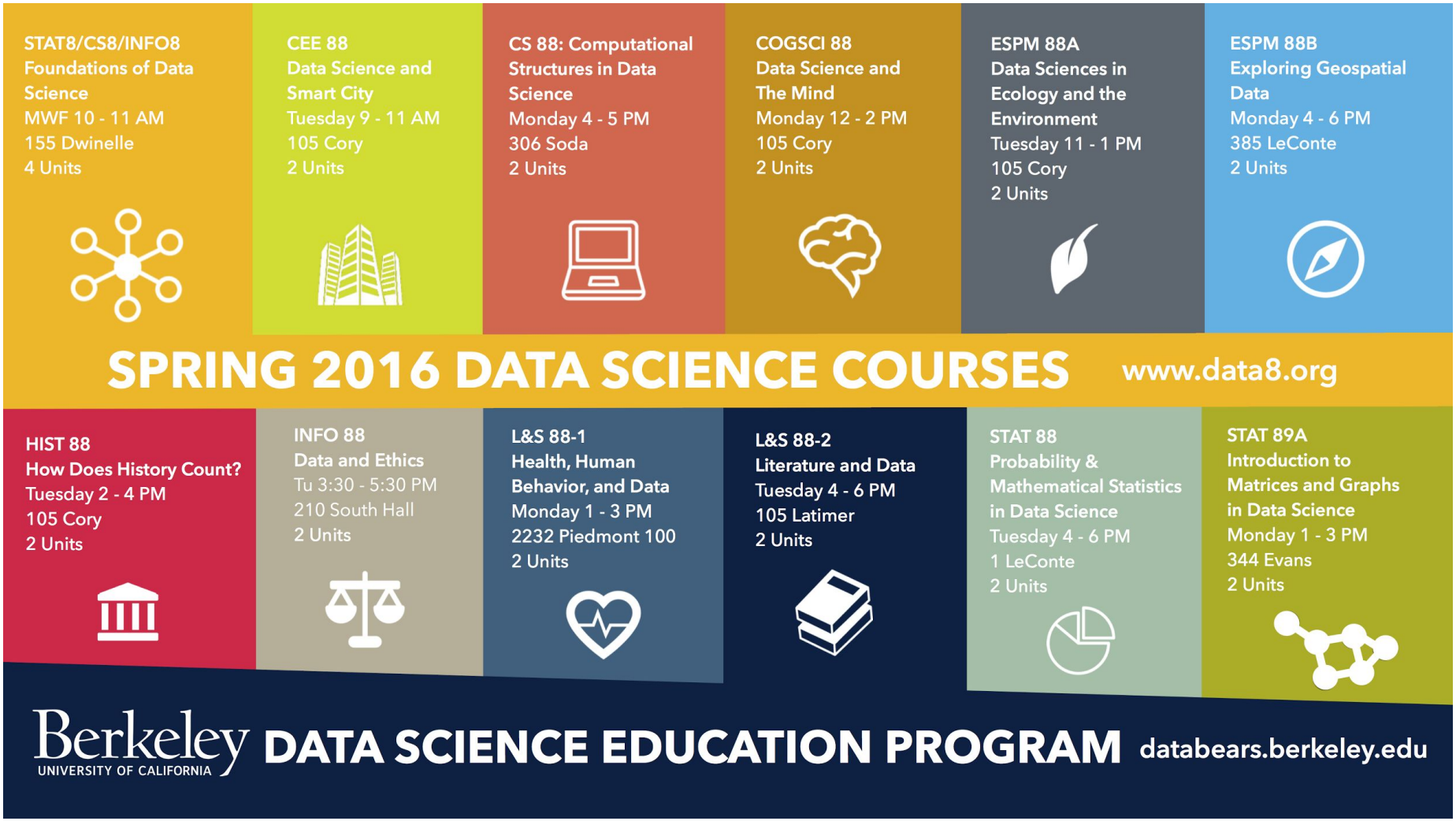


Modified from a diagram by Jessica Hamrick

Technical specs

- Fall 2015 pilot (about 80 students): deployed JupyterHub on bare-metal machines from Berkeley's CS dept
- We gave each student 2GB of RAM
- Expected about 60% of users to be on at any time, so we provisioned 2 machines each with 64 cores + 26GB RAM
- Spring 2016 (about 480 students): we deployed on a donation from **Microsoft Azure**, using 36 machines each with 8 cores + 14GB RAM

Connector courses



Connector courses

- **Suite of courses** in departments across campus introduce diverse subjects through the lens of data science
- Spring 2016 has 11 connector courses: in ethics, cognitive science, geospatial data, statistics (2), ecology, history, computer science, health, smart cities, literature
- Nearly all use Jupyter notebooks and the DATA 8 JupyterHub deployment, Interact links, etc.
- Many connector instructors are new to Python & GitHub!

Technical challenges & possible future directions

- Scaling up to more students
- Scaling out to more courses

Scaling up to more students

- Theoretically, scaling up to more students means we can just add more nodes to the JupyterHub deployment to get the computing power in. However...
- ...we're now discovering bugs that are only discoverable when dealing with scale.
- We were haunted by **a race condition** in JupyterHub that resulted in many 503 errors for weeks.
- We made a forum thread for these issues, though reports of trouble have greatly declined since we upgraded to JupyterHub 0.5.0.

Scaling up to more students

- Now we have a team of students adding tooling to make deployment more stable

- This includes a **development deployment**, **logging and monitoring**, and **load testing**

Scaling out to more courses

- Goal: eventually have one JupyterHub deployment that can serve any courses at UC Berkeley that want to use Jupyter notebooks
- Adding JupyterHub for a course should be as easy as creating a class web page
- JupyterHub currently consolidates all users into one system -- we need to split the users into multiple groups

Scaling out to more courses: Some challenges

- Courses have different resources -- some might have AWS credits, others can have Azure credits, etc.
- Instructors need a way to distribute content to students
- Ideally, instructors could also grade assignments easily
- Students should be able to access different hubs for different courses, and build a portfolio of materials over their undergraduate years

Scaling out to more courses: Some proposals

- A JupyterHub Hub, which lists and manages deployments of JupyterHub
- A Dropbox-like interface to GitHub to help instructors with content management
  - See the **design doc** for an experiment called **jupyter-synchronized-folders**
  - The design doc is structured as (but is not) a **Jupyter Enhancement Proposal**
  - We'd love to hear comments via **this pull request**

Some other resources

- **jupyter-education Google Group**
- **JupyterHub Gitter channel**

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Data Science Connector Course Instructors

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Shanaaz Deo
Michele Gleit
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Anthony Suen
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